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AN INTERMEDIATE COLLEGE COURSE IN PERCEPTION AND JUDGMENT DESIGNED TO INCREASE THE RANGE AND INTENSITY OF STUDENT PARTICIPATION.

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THE OBJECTIVE WAS TO INCREASE THE DEGREE OF ACTIVE PARTICIPATION IN THE LEARNING OF CONTENT AND METHODS IN THE AREAS OF PERCEPTION AND JUDGMENT. TWO TYPES OF MATERIAL WERE DEVELOPED--(1) READING NOTES AND WRITTEN LECTURES, AND (2) DEMONSTRATIONAL APPARATUS. ELEVEN STUDENTS TOOK THE COURSE DURING A 2-YEAR PERIOD. THEIR HELP IN EVALUATING THE NEW CLASS FORMAT WAS SOLICITED AT SEVERAL POINTS DURING THE SEMESTER AND AT THE END. WITHOUT EXCEPTION, THE STUDENTS SAID THEY PREFERRED THE NEW ARRANGEMENT TO THE CONVENTIONAL ONE. THE COURSE FOR WHICH THE MATERIALS WERE DESIGNED RELIES HEAVILY UPON ORIGINAL STUDENT PROJECTS WHERE EACH STUDENT DESIGNS AND CARRIES OUT THREE PROJECTS DURING THE SEMESTER. A LIST OF COMPLETED PROJECTS DURING THE TWO SEMESTERS IS GIVEN. THE LECTURES, READING NOTES, DESCRIPTIONS AND PHOTOGRAPHS OF APPARATUS, AND SELECTED COMMENTS FROM STUDENT COURSE EVALUATION ARE INCLUDED IN THE APPENDIXES. ON THE WHOLE, THE PURPOSE FOR WHICH THE MATERIALS WERE DEVELOPED WAS ATTAINED. IT WAS FELT THAT A SIGNIFICANT STEP HAD BEEN MADE IN THE DIRECTION OF EFFECTIVE TEACHING AND THE STUDENTS APPEARED MORE INTERESTED THAN PREVIOUSLY. (GC)

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# AN INTERMEDIATE COLLEGE COURSE IN PERCEPTION AND JUDGMENT DESIGNED TO INCREASE THE RANGE AND INTENSITY OF STUDENT PARTICIPATION

Cooperative Research Project No. S-141

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## TABLE OF CONTENTS

Page

PROBLEM. . . . . . . . . . . . . . . . . . . . . . . . . 1

OBJECTIVES. . . . . . . . . . . . . . . . . . . . . . . 2

PROCEDURE. . . . . . . . . . . . . . . . . . . . . . . . 2

THE MATERIALS. . . . . . . . . . . . . . . . . . . . . . 3

STUDENT PROJECTS. . . . . . . . . . . . . . . . . . . . 7

STUDENT EVALUATIONS. . . . . . . . . . . . . . . . . . . 8

APPENDIX I. . . . . . . . . . . . . . . . . . . . . . . 11

APPENDIX II. . . . . . . . . . . . . . . . . . . . . . . 117

APPENDIX III. . . . . . . . . . . . . . . . . . . . . . 124

## PROBLEM

The psychology of perception and judgment was the area of concern in the curriculum improvement project reported below. The topics generally included in this area are the following: the detection and recognition of stimuli, the perception of form, the perception of size and distance, the perception and judgment of sensory magnitudes, and the effects of motivation and learning on any of the above.

Although the study of perception and judgment is the oldest topic in experimental psychology, it is now given relatively little emphasis in most undergraduate curricula. Its gradual disappearance from undergraduate (and graduate) instruction in most schools paralleled the growth of behaviorism and the selection of learning as the central topic of American experimental psychology. The past decade has seen a reversal in the declining importance of perception. Following recommendations by the American Psychological Association, laboratory courses specifically oriented toward this area have begun to appear or reappear in many college curricula.

Two major difficulties face the teacher who wishes to present an intermediate or advanced undergraduate course in perception. The first is the paucity of appropriate text materials. Perception is very under-represented in the text field when compared with the learning, motivation, personality, physiological psychology and social psychology. It is therefore necessary to rely upon journal articles and selections from advanced monographs for course assignments. These make difficult reading, particularly at the intermediate level,and require a good deal of repetition of the materials in the lectures, thereby limiting the amount of material that can be covered in a semester's time. The premature assignment of advanced materials is also rather discouraging to the student.

The second major difficulty is the lack of reasonably priced, flexible apparatus for demonstrations and student experiments. Demonstrations and experiments are particularly important in teaching perception because of the phenomenological nature of much of the material. Regardless of whether the final description of the results of perceptual research makes use of phenomenological or behavioristic constructs, the processes studied in the research almost always have phenomenological aspects. These aspects are difficult to describe verbally or to represent diagrammatically.

Students often find it difficult to understand what is being discussed in an experimental report until they have been exposed to the experimental stimuli and have experienced the phenomena elicited by the stimuli. The functioning of perceptual processes are much more frequently taken as self-evident and nonproblematic than are processes of learning or motivation. Therefore, direct experiences by the student are necessary for him to understand why some aspect of perception poses any problem at all. Once again it should be emphasized that the importance of direct experience of perceptual phenomena is pedagogical rather than theoretical.

## OBJECTIVES

The objectives of the curriculum materials developed were to help the student to attain a thorough understanding of the concepts and phenomena in selected areas of perception and judgment; to increase his ability to make effective use of research reports and other advanced materials; and, finally, to further the conceptual and methodological skills involved in the selection of research problems and the design and execution of research concerning these problems.

## PROCEDURE

Two types of material were developed to achieve the objectives mentioned above. The first was a series of dittoed reading notes and written lectures. These were distributed to students in advance of the class meeting on a given topic and were designed to orient the student toward the central aspects of the material being covered. Class meetings about topics for which notes were prepared were devoted primarily to demonstrations and discussions rather than to simply exposing the student to information via lectures. The topics for which no notes were prepared were covered in more conventional lecture-recitation meetings. An informal comparison of students' reactions to the two styles of instruction provided one of the major methods of evaluating the success of the experimental instruction plan.

Most of the time and funds involved in the project were devoted to the creation of a second type of curriculum material, namely, demonstrational apparatus. An attempt was made to design and reproduce pieces of equipment which would be useful for experiments and demonstrations in a wide variety of perceptual areas. Some of these pieces of equipment were relatively standard, while others involved considerable innovation. The general purpose of each piece of equipment to be built was determined by the principal investigator.

The detailed planning, the more technical parts of the construction and the supervision of the routine parts of the construction were carried out by an extremely gifted undergraduate assistant, Mr. Frederick Wightman. During the 1964-65 academic year he was assisted by another student, Mr. Ramsay Liem. In addition, students were hired to help with specific construction jobs.

## THE MATERIALS

Because the project was not primarily oriented toward research, there are few data to report. These consist of wirtten student comments about the course and will be presented later. This section will list, and, where appropriate, describe the materials developed. Copies of the written materials and more detailed descriptions and photos of some of the equipment are included in the appendix.

### Lecture Notes*

1. Structuralism: the beginning of the scientific study of psychology. (12-31)

2. Introduction to Gestalt Psychology. (32-46)

3. Testing Gestalt theory concerning the dynamic effects of shape. (47-54)

4. The quantitative study of form. (55-58)

5. Some comments on threshold theories. (59-65)

6. Attention and vigilance. (66-69)

### Reading Notes*

1. Allport, F.H., Theories of perception and the concept of structure. Ch. 4. (70-72)

2. Köhler, W., Gestalt Psychology. Chs. 2,3,4,5. (73;85; 76-80)

3. Hochberg, J., Triebel, W. and Seaman, G., "Color adaptation under conditions of homogeneous visual stimuation." (74)

4. Katz, D., "The modes of appearance of color." (74)

5. Gelb, A. and Goldstein, K., "Analysis of a case of figural blindness." (74)

6. Köhler, W., "Gestalt Psychology today." (75)

7. Wertheimer, M., "Principles of perceptual organization." (80)

8. Koffka, K., "Points and lines as stimuli." (80)

9. Fuchs, W., "On transparency" and "The influence of form on assimilation." (81)

10. Fuchs, W., "Completion phenomena in hemianopic vision." (82-3)

*The numbers in parentheses refer to the pages in Appendix I on which the readings can be found.

11. Wallach, H., "Brightness constancy and the nature of achromatic colors." (84-5)

12. Köhler, W., Dynamics in psychology. Ch. 2. (85-6)

13. Werner, H. and Wapner, S., "Toward a general theory of perception." (87-9)

14. Witkin, H., "The nature and importance of individual differences in perception." (90)

15. Woodworth, R. and Schlossberg, H. Experimental psychology, Rev. Ed. section entitled "Pursuit movements and the perception of motion." (91)

16. Koffka, K., "Perceived motion." (91)

17. Wallach, H., "The perception of motion." (92)

18. Koffka, K., Gestalt Psychology. Ch. 7. (92-4)
18a. Wallach, H. "On the Constancy of Visual Speed." (95)
19. Hebb, D.O., The organization of behavior. Chs. 1,2,3,4,5. (96-101)

20. Dember, W., Psychology of perception. Chs. 2,4. (102)

21. Galanter, E., "Contemporary psychophysics." (103)

22. Swets, J., "Is there a sensory threshold?" (104-5)

23. Miller, G., "The magical number seven, plus or minus two: some limits on our capacity for processing information." (106)

24. Broadbent, D., Perception and communication. Chs. 2, 3,4,5,6, and 9. (106-8)

25. McGrath, J., "Irrelevant stimulation and vigilance performance." (109)

26. Jerrison, H. and Pickett, R., "Vigilance: a review and re-evaluation." (109-10)

27. Jerrison, H. and Pickett, R., "Vigilance: the importance of the elicited rate." (111)

28. Eriksen, E., "Discrimination and learning without awareness: a methodological survey and analysis." (112-6)

Apparatus*

1. Variable intensity ganzfeld. This device consists mainly of a large sheet of translucent plexiglass mounted in a curved frame and indirectly illuminated by six variable intensity light sources. (The intensity control unit can be used separately.) Its major use is in connection with discussions of the Gestalt theory of perception. (125)

2. Superimposed visual field viewing box. This is an L-shaped box whose two chambers are separated by a half silvered mirror. It permits one to superimpose one visual stimulus on top of another as though one were looking at a photographic double exposure. It was used in connection with Gestalt studies of transparency and assimilation. (126)

3. Rod and frame device. This is a standard piece of apparatus used to illustrate the effects of visual and bodily stimulus contexts on the perception of the visual vertical. (127)

4. Tilting chair. A chair fitted with a head rest and straps and mounted on a gimbals. It is used along with the rod and frame.

5. Motion machine. An apparatus which drives a continuous opaque belt, with cutouts, in front of an illuminated screen. This is used to study a variety of phenomena relevant to the perception of motion. Two of these complex machines were built because many of the applications require the comparison of two moving fields. (128)

6. Kinetic depth effect projection box. This is a long box with a rear projection screen at one end. Inside the box is a projector and a motor. Between the projector and screen a wire form is mounted on the motor shaft so that its shadow falls upon the screen. It is used in the study of depth perception. (129)

7. "Common fate" apparatus. Two plexiglass sheets are mounted in a three-sided frame, with a white back and an open front. Various arrangements of dots are painted on the sheets. When the sheets are stationary, one visual pattern is seen. When one sheet is displaced with respect to the other, the dots moving together form separate patterns. This is used in demonstrating some Gestalt principles. (130)

8. Prisms mounted on plastic goggles. These are used to study adaptation to distorted visual fields.

*The numbers in parentheses refer to the pages in Appendix III on which descriptions and photographs of the apparatus can be found.

9. **Equivalent configuration boxes.** This is a set of three boxes, each containing a string tightly suspended between two rods. The subject looks into the box through a peephole at one end at the string. The strings are arranged so that they project extremely similar visual images despite considerable differences in physical arrangement. The boxes are used to study the effects of learning on perception. (131)

10. **"Thereness-thatness" apparatus.** This is a complex apparatus for studying distance perception. It permits the variation of many variables affecting the location of objects in space. (132)

11. **Photographic slides.** A large number of photographic slides have been prepared for lecture illustrations, demonstrations and student experiments. Although many of the slides are prepared for specific student projects, most are kept so that they can be used again. Building a library of such slides increases the number of experiments a student can perform without time-consuming preparation of materials. (133)

12. **Projector adapters.** Very inexpensive, 50-watt projectors were altered so that they could be fitted with filters and used as projectors or precision spotlights. These have been used in an enormous number of experiments and demonstrations.

13. **Miscellaneous equipment:** adjustable head rests, stimulus holders, reduction screens, rear projection screen, data transmission hookups, and episcotester.

STUDENT PROJECTS

The course for which the materials were designed relies heavily upon original student projects. Each student designs and carries out three projects during the semester. Listed below are some of the projects that were completed during the two semesters included in the contract period. These illustrate the major ways in which some of the materials were used.

Spatial preference for partial information. Photographic slides of words.

Proximity as a factor in visual organization. Stimuli drawn on posterboard.

Determinants of the kinetic depth effect. Kinetic depth effect projection box.

The effects of order of attention and report on information processing in visual perception. Photographic slides of geometrical forms.

Vigilance and important signals. Tape-recorded signals and distracting words, and data transmission hookup.

Figural after-effects and the perception of verticality. Rod and frame apparatus.

The perception of inverted faces in pre-school and school children. Photographed pictures of faces.

Perceptual readiness and the perception of tachistoscopically-flashed stimuli. Photographic slides of letter arrangements.

The "verbal-loop" hypothesis and the use of imagery in coding sensory input. Photographic slides of geometric forms.

A quantitative study of the paradoxical distance effect. Photographic slides, using several of the small projectors simultaneously.

Expectancy and payoff matrices. Tape-recorded messages and data transmission hookup.

Random stimulation and "sensory lag." Rod and frame apparatus.

Target variables and perceived velocity. Motion machines.

The effects of visual cues and assumptions on perception. Equivalent configuration boxes.

STUDENT EVALUATIONS

A total of 11 students took the course during the two-year period covered by the contract. They were told that the preparation of lectures and reading notes and the construction of demonstration materials were being supported by a contract with the Office of Education. Their help in evaluating the new class format was solicited at several points during the semester and at the very end.

The small number of students involved made a formal analysis of the written evaluations inappropriate. Instead, the general ideas presented by the students are summarized here and a number of passages from the evaluations are quoted in Appendix II. In assessing the statements, several factors should be kept in mind. The first is that the students might have felt constrained to give favorable comments to support their teacher's project. The second is that although the written comments were anonymous, the small size of the class and the fact that most of the students were psychology majors may have inhibited negative remarks. Although the teacher would not know who made negative criticisms, he would know it was one of five or six persons. Finally, it should be recognized that the course plan fits very well into Haverford students' opinion about how courses ought to be run. They therefore might have been motivated to praise the outcome, regardless of its actual value.

In general, the students were quite positive about the use of the notes and demonstrations; some were very positive. They believed that the notes helped them get something out of what might have been hopelessly difficult readings. They also believed that the notes made for good class discussions in several ways, namely, facilitated understanding, freed class time that would otherwise have been spent listening to lectures, and motivated students to do the reading. This last point might be understood better when it is recognized that in a class of five or six, the probability of being asked to contribute to a discussion is very high. The students knew that they would be called upon to answer some of the questions. The guides provided by the notes gave them an adaptive way of dealing with what was probably a worrisome situation.

There were two negative comments about the reading notes. The first was that the questions asked sometimes focused on details to the exclusion of the overall significance of the readings. This was probably an important flaw in some of the notes, particularly since the place of the reading in a larger context was the most difficult thing for the students to grasp on their own. The second criticism was that the student was tempted to use the notes as a substitute for an analytic approach rather than a guide. It was felt that some read the articles only to find the answers to the questions in the notes. While this might be superior to a completely passive approach, it was not the use of the notes preferred by the author.

Comments were also generally positive about the many class demonstrations. It was probably more difficult for students to evaluate this aspect of the procedure than the notes. The aspect of the course relevant to demonstrations was much less comparable to other courses than were the notes and discussion aspects. Nevertheless, many did believe that the demonstrations gave fuller and clearer meaning to the material they read. Some also commented upon the motivational function of the demonstrations; they were often quite interesting and enjoyable in their own right. The major problems noted with the demonstrations were that they sometimes did not produce the intended effect and that they were rather time consuming.

Probably the most impressive support for the use of the notes and demonstrations comes from the comments comparing the part of the course in which these were used with the part taught more conventionally. Without exception, the students said they would have preferred the new arrangement to the conventional one. The second time the course was taught, the author distributed Xeroxed copies of his actual lecture notes in an attempt to obtain some of the benefits of the more complete written lectures. This attempt did not succeed. The major reason probably was that the specially prepared written lectures were not outlines but were fully developed; they also were written for reading, not for delivery.

## CONCLUSIONS AND IMPLICATIONS

On the whole, the purposes for which the materials were developed were attained. An important course which was particularly difficult and not well liked was made more effective and attractive. The methods used appear generalizable to other courses as well. Lecture and reading notes can be used with any content. Demonstrations or case materials also can be used in a variety of areas.

A comparison of the author's experience in the course during the past two years with his experience teaching it for five previous years also supports the view that a significant step had been made in the direction of effective teaching. The amount and quality of class discussion improved severalfold over previous years. The students were also better prepared and appeared more interested than previously.

No attempt was made to compare the quality of student research or exam performance before and during the project period. Although the equipment permitted a wider variety of projects, there did not seem to be any striking increase in the quality of the projects. The exam performances during the project also did not differ in any impressive way from the previous period.

One of the major drawbacks to the procedure is the amount of time needed to prepare the notes and demonstrations. Writing lectures to be read is considerably more demanding than outlining material for oral delivery. Similarly, preparing explicit comments and questions on readings takes much more effort than reviewing them for informal class discussion. In the present case the added preparation time appears to have yielded a good return.

The fact that the author was given a modest stipend to spend a few summer weeks thinking about the course and preparing materials was of great benefit. Only in the summer can one have the time and release from the pressure of academic demands to do the kind of intensive examination and reworking that the new type of course requires. Courses prepared "on the run" are bound to be spotty. Had an entire summer been devoted to the present course, it could have been entirely reworked. Despite intentions to the contrary, it was not possible to do much of the notes preparation during the semester. The time available for the course was taken up by the meetings, reviews of material on preparation of meetings, setting up labs and demonstrations and supervising research.

Although it is somewhat out of place, I would urge the Office of Education to consider a special program of curriculum development contracts whose primary purpose is the support of a faculty member for an eight to ten-week period for the sole purpose of reworking a course and developing the kind of instructional aids used in the present project.

# Appendix I

## Lectures and Reading Notes

## Structuralism: The Beginning of the Scientific Study of Psychology.

Surprisingly, we begin our study of perception at the beginning or very close to it. Our brief treatment of structuralism, or introspectionism as it has sometimes been called, has three purposes. The first is to provide a brief excursion into the history of ideas, the study of how ideas evolve and influence each other. The second is to give you a feeling for, if not a sympathy for, the major thrusts of structuralism because these thrusts eventually stimulated two revolutionary movements, Behaviorism in America and Gestalt Psychology in Europe.* The final purpose is similar to the first in that it traces the direct descendants of structuralism ideas to the present day. These descendants will be introduced and then put aside for more intensive treatment later on.

### The Origins of Structuralism.

The latter half of the 19th century must have been a wonderful time for intellectuals. The experimental method had already begun to yield impressive results in the biological and physical sciences. Atomic theory in chemistry and evolutionary theory in biology gave promise of finding the basic principles which governed nature. The decades of peace following the defeat of Napoleon led many to believe that man had finally risen to a higher plane of existence than before and that continued progress toward peace and prosperity was the inevitable consequence of the expansion of knowledge. Little of the new knowledge was so technical that it was beyond the grasp of the intellectual of the 1860's. There were general scientific periodicals which enjoyed wide circulation and in which intellectuals could exchange ideas about the advanced scientific topics of the day.

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* If one adds Psychoanalysis to the two revolutionary movements already mentioned, he has encompassed the basis and much of the content of modern psychology. Freud's revolution, however, was not stimulated by structuralism; it was more or less concurrent with it, but had nothing to do with it for reasons which will become obvious.

All of the scientific knowledge rested upon a thorough background in philosophy. A chemist who was a Doctor of Philosophy, was so in reality, not in name only as is generally true today. Given this matrix of knowledge which, if not integrated, was at least simultaneously available to thinking men, it is not surprising that many began to move toward the application of the experimental methods to one of the outstanding problems of philosophy. The problem was how men gained information about the world; the branch of philosophy which sought its solution was known as epistemology. This had always been one of the dominant interests of philosophy, but the 19th century saw it become the dominant interest, particularly in Great Britain.

The British philosophers appeared to agree that man gained primary knowledge through his senses; i. e., through the effects of the environment on his eyes, ears, etc. While this may seem to us like the only answer that could be given, it is not. We could believe that much of man's knowledge is built in; people who hold that there is an inborn sense of right and wrong take a similar point of view. We could believe that some knowledge comes through divine inspiration; once again this view is currently popular only with regard to knowledge concerning morals. We might also believe that there are non-sensory channels through which we obtain information; a few highly respected psychologists continually caution their fellows not to disregard completely the problem of extra-sensory perception. In any event, the non-sensory sources of information were by and large rejected by the British philosophers who were therefore given the title "empiricists."

The empiricist solution to the problem of epistemology fell upon the receptive ears of physiologists who were busy discovering all kinds of interesting things about the sense organs and nerves and was also well received by physicists concerned with various kinds of radiant energy, e. g. light, heat, sound. The experimental investigation of sensation and perception could hardly help but being born in such an intellectual milieu. It is hard to say just when or where it was born. Wilhelm Wundt is generally credited with opening the first psychological laboratory at Leipzig in 1879. Despite the number of cigars which were undoubtedly smoked upon the occasion of this blessed event (19th century intellectuals were notorious cigar smokers), it is clear that psychological research on sensation and perception was underway as early as 1834, when E. H. Weber published (in Latin) his findings of his research in sensation. We shall have more to say about Weber later in the semester. Let us return for the moment to Wundt.

The combination of titles this venerable gentleman held is symbolic of the undifferentiated climate in which the modern form of our discipline began. He took his doctorate in MEDICINE (physicians were leading intellectuals in those days); he taught PHYSIOLOGY for a few years and then moved to Leipzig as a professor of PHILOSOPHY. His first major work was called PHYSIOLOGICAL PSYCHOLOGY and contained very little biology. He founded a journal called PHILOSOPHICAL STUDIES which was exclusively devoted to the publication of results and discussions of psychological experiments, most of which were carried out under his supervision. This combination which seems so odd to our modern minds was typical of Wundt's time. The "new psychology", as it was then called, was generally taught in philosophy departments until after the first World War. In some protected environments, this practice continued into the 1920's. (Haverford's Psychology Department was separated from Philosophy in the middle 1940's.)

## The Structuralist Orientation.

The proper study of psychology. Much to the horror of John B. Watson and most American experimental psychologists, the structuralists believed that the proper study of psychology was awareness or consciousness. For them psychology was the study of sights, smells, sounds, feelings of tension in the muscles, coldness in the feet, joy in the "heart" (actually they would probably have located joy further toward the feet), other emotions, thoughts, images, etc. Edwin B. Titchner, an Englishman who studied with Wundt in Germany and taught at Cornell University, wrote the definitive structuralist textbook in English. He defined psychology as the study of immediate experience, the study of experience conceived of as a property of the person having the experience. He distinguished this from the physical sciences which he said studied mediate experience, that is experience conceived of with reference to the environmental objects giving rise to the experience.

The experience I have as I look at the plant on my filing cabinet would be studied from the structuralist point of view by analyzing it into its elements, e. g. color, size, clarity of the countours of the leaf, and by dredging up the other parts of my immediate awareness as I look at it, e. g. a vague feeling of discomfort and the idea that the plant is not getting enough light. The biologist who experiences the plant does not deal explicity with the clarity of the countour of the leaf he sees or the portion of his visual field that is occupied by the plant. Rather he deals with his experience in terms of the plant itself. (Not being a biologist I cannot pursue this example much further from this point of view other than stating that the plant is called nephthitis, a name which always reminds me--the psychologist, that is,--of a kidney disease.) The physical scientist looks at experience for the information it mediates or carried about environmental objects and events. Most of us, most of the time, deal with experience as the physical scientist does. It, per se, is not the object of our concern; indeed we generally are not aware of being aware, except when made self-conscious by confusing, troublesome sorts such as psychologists or philosophers. It is only with respect to our emotions and internal aches and pains that we have much practice in dealing with the immediate experience the structuralists wished to study.

*Psychology's Mendeleyevs*. Although there is no certain evidence, it is likely that, as he was helped on with the academic robes in which he always lectured, Titchner puffed dreamily on his cigar and thought of the day when he or one of his devoted students would be able to unfurl a relatively complete table of mental elements before his audience. Such was the ambitious task that the structuralists had set for themselves. Immediate experience was to be analyzed into its elements or constituent atoms. These were to be classified into functionally related groups such as sensations, images, and feelings. The nature of their combination into actual complex experiences was also to be set forth. John Stuart Mill may have invented the term "mental chemistry" as a striking metaphor, but the structuralists' program turned it into an accurate label.

One may be amused or indignant at the psychologist's appropriation of the chemists' terminology because while the chemists were describing real things with their table of elements, the psychologist was not. The psychologist, it might be argued, was using the chemists' description of matter as a model or analogy in terms of which he hoped to describe immediate experience. Such an argument would be quite accurate, although Titchner would probably have staunchly defended the reality of his elements. It would, however, be incomplete unless it recognized that the chemists' application of the concepts of the atomic theory and Mendeleyev's ordering of the elements also exemplified the use of analogies and models in science. The relation between scientific theory and analogy is a point to which we will return frequently during the semester.

### Physiology and Psychology: The Body and the Mind.

Despite their reliance on chemistry for the basic outline of their endeavor, the structuralists made much more use of the physiology, particularly the neurophysiology of their day. They accepted the doctrine of psychophysical parallelism which held that for every conscious experience there was a coordinate or parallel physiological process. (Note that the reverse is not at all necessarily true. There are many physiological processes which have no conscious counterparts.) If, at the outset of the search for the basic atoms of experience, one assumes psychophysical parallelism then it is only natural that the findings and speculations of neurophysiology are going to influence where one searches. And so it was. The sensory elements to be found were assumed to be the direct consequence of the stimulation of sensory receptors and the subsequent excitation of the projection areas of the cortex. For every sensory element there had to be some corresponding specific aspect of the physiological processes involved in the reception of stimulation.

The assumption described sounds suspiciously like the doctrine of the specific energy of nerves formulated a half century earlier. That doctrine held that the stimulation of a given sensory nerve (a nerve leading from a receptor to the central nervous system) would lead to the experience of a single quality, regardless of how the nerve was stimulated. For example, whether our eye is struck by light as we gaze into the Milky Way or by the fist of a local hood, we see stars. The structuralists went considerably further than the doctrine of the specific energy of nerves. In effect, they refused to consider an experience as elementary unless they could point to some aspect of the physiological process to which it could correspond.

Let us try to see the matter from the structuralist point of view. Like all men of the 19th century, they were convinced of the unity of science, not as a distant goal, but as something already partly within their grasp. By the beginning of the 20th century, much of the major anatomical work relating the receptors to the central nervous system had been completed. There were many reasons to believe that there was little left to discover concerning the workings of the sensory aspects of the nervous system. This conviction was to remain among many psychologists until the advance in electronics made more detailed investigations of the sensory process possible. Wasn't it reasonable therefore to use the "established" knowledge of physiology as a criterion for dividing reasonable from unreasonable speculation in psychology?

Perhaps this is being too kind to the structuralists because by the time psychology became a specialty in its own right, e.g. 1890 or so, most psychologists were not also physiologists and their reliance on a conception of the nervous system was not based on their own research experience, but on what they had learned in the course of their graduate studies. Knowledge in the other fellow's discipline always seems more certain than it does in your own, particularly if his discipline is closer to physics than yours. Indeed, apart from the a priori notion of psychophysical parallelism, and its consequences, the second generation of "new psychologists", i.e., those trained by men like Wundt, had little first hand contact or interest in physiology. Despite the fact that his great teacher's text was called PHYSIOLOGICAL PSYCHOLOGY, Titchner explicitly ruled the study of physiological processes out of psychology because it was not the study of experience. Such rigid reliance upon limits set by current knowledge of physiology was not limited to the structuralists. It has interfered with the study of psychology in a number of areas, particularly when the physiological conceptions giving rise to the limits were themselves no longer highly regarded by those on the forefront of physiology. As we shall see, the inflexible reliance upon a specific conception of nervous system functioning was one of the reasons for the demise of structuralism.

Psychophysical parallelism affected not only the elements the structuralists were willing to consider, but also the processes they were willing to consider as responsible for creating "mental compounds." The major process was that of association, a linking together of previously discrete elements. This corresponded to the linking together of separate neural units. In all fairness, physiology should not bear the entire responsibility for the reliance upon association as the major mental process. The responsibility probably goes back to Aristotle, but the British empiricist philosophers devoted great effort to describing the "laws" of the association of ideas, images, and sensations. The physiologists' conceptions of the neural linking process and the psychologists view of mental association both sprang from the same philosophical root.

For the physiologist and the psychologist of the late 19th and early 20th centuries, the nervous system could be conceived of as a telephone system. Physically discrete messages were received in the projection areas of the brain from each of the nerve fibers in the sensory organs. These messages travelled along insulated pathways and hence did not influence each other, as should be the case in a well designed telephone system. Once in the brain or switchboard of the system they were shunted over incredibly complex, but nonetheless discrete, traceable pathways until they found their way to a motor area of the brain. They were then relayed once again along discrete pathways to their final destination in some muscle fibre or gland cell. In neurophysiology all one had to do was to trace the pathways. In psychology all one had to do was to study the associations.

Although the description of the switchboard conception of the nervous system is oversimplified, it does convey flavor of the structuralist outlook. They were basing their ideas on what seemed to them advanced scientific models. If their ideas sound naive, we need only look at current attempts to model psychological and neurophysiological processes after computers.

Unfortunately it is so difficult for us to imagine how modern telephone systems work that we are willing to trust that computer models may be sufficiently complex to serve as appropriate models for psychology and physiology. Perhaps they are; it is certainly reasonable to think so today just as it was reasonable to think as the structuralists did 55 years ago. If we differ from them it is only because we are a bit more self-conscious and flexible about our use of models. Our models are more abstract and complex; ideally they should allow more precise derivations. However, the ultimate test of a model is whether it fits the data it is intended to explain. It was this test that the atomistic, connectionistic model constructed by Titchner in the early 20th century failed to pass. But before we come to its end there is one more aspect of the orientation we must consider.

The art of introspection. We have seen that the structuralists intended to investigate the atoms of experience and the modes of their combination within the limits set by the then current notions of neurophysiology. Wundt, Titchner, *et alia*, were not types to leave such discoveries to chance. Not only did they know what they wanted to find; they knew how they were going to find it. They were going to use introspection. In everyday parlance, introspection calls to mind Hamlet-like brooding over the sources of one's feelings and actions. This is not the kind of introspection used by the structuralists. For them introspection was a method of treating one's own experience as something to be observed, that is, of treating it as immediate rather than as mediate. This requires that all meaning or reference to things and events in the environment be purged from experience. Such introspection is more easily described than accomplished. Occasionally by looking at something long enough, it loses its thinglike character and becomes simply a collection of sensory qualities, varying along a number of dimensions. The purging of meaning from experience may sometimes be more easily achieved in the auditory modality when we repeat or hear someone else repeat the same word again and again. At some point many people report that the word begins to sound like a nonsensical collection of sounds. If we have achieved this nonsensical, or meaningless tone in our experience, we have begun to introspect in the analytic fashion required by the structuralists. We have refined away the impurities and are left with the true elements of experience. Only after we had achieved the skill of making things meaningless would we have been allowed to begin our research into psychology. It is little wonder that

Wolfgang Köhler, one of the instigators of the Gestalt revolution, wrote about breaking out of "the prison which was psychology as taught at the universities..." during the hegemony of the structuralists.

## The Decline and Fall of Structuralism.

Unlike the Roman empire, structuralism did not crumble because of sloth and lechery on the part of its leaders. They were, to the contrary, tireless workers. Boring, a student of Titchner, claims that graduate students at Cornell were expected to spend about 80 hours a week around the lab. Wundt wrote a total of some 50,000 pages of texts and articles during his lifetime. With such industry we needn't inquire into lechery or any other vice; no structuralist would have the time or energy left for such unprofessional behavior.

Structuralism was brought down by the materials and methods used in its construction and not by the construction workers. In the first place, the cataloguing of elements proved to be close to impossible. Boring reports that by 1893, Külpe had reported "696 discriminably different visual brightnesses, 150 hues, 11,063 tones, three touches, four tastes and numerous smells." In 1896 Titchner reported 32,820 colors (these combine hues and brightnesses), "11,600 tones, a huge number of smells, four tastes, four cutaneous qualities, two qualities from muscle, one from tendon, one from joint, three more or less from the alimentary canal, one for sex, one for the static sense - a total of more than 44,435.

As against the 64 then known elements of chemistry, the mind seemed to be pretty well provided for."

Indeed fairly early in the game it was suspected that the idea of elements might have to give way because there were too many and also because some of the attributes describing the elements, e. g., intensity, clarity, duration or extension, seemed to fit a wide variety of sensory qualities. Substituted for the element model was a dimensional model. Experiences were to be described by locating on the basic dimensions of consciousness. This was certainly a more manageable task than counting elements. If the overwhelming numbers of elements were the only problem of the structuralist approach, the movement would have survived.

A second problem was that some elements or dimensions refused to be independent, despite the fact that they could not be reduced to simpler elements. This was unheard of in chemistry. In that science, if you are sufficiently careful, you can accumulate whatever amount of one element you wish, without simultaneously getting more of a second. But in psychology, if you held the physical intensity of illumination constant and varied the wave lengths from low to high, the experienced intensities of the colors increased and then decreased, despite the fact that intensity was supposed to depend upon wave amplitude and not wave length. Experienced hue and intensity were not independent. A similar relationship occurs between the supposedly basic auditory dimensions of pitch and loudness. Such findings could not be incorporated into the structuralist model.

Another related difficulty was that some basic dimensions did not have specific classes of physical and physiological processes with which they could be perfectly correlated. There were some irreducible sensory dimensions for which no physiological processes could be suggested, e. g. the experience of volume in sound and much more importantly the experience of form or shape. Titchner refused to accept the latter as a basic unanalyzable experience because he could conceive of no corresponding physiological process.

Finally the method of introspection provided no way of resolving disagreements. If, as is reported to have happened, Titchner and some other well-known psychologist disagreed on the dimensional location of the experience elicited by a given stimulus during a demonstration before an early meeting of the American Psychological Association, what was to be done? Titchner reportedly resigned from the Association and founded the Society for Experimental Psychology (which still exists). This, however, is hardly an elegant way of settling scientific disputes. And the exclusive reliance upon analytic introspection as the only psychological method made such disputes inevitable. And so structuralism ended, or did it?

## Structuralism Today.

By the middle of the 1920's the formal program of structuralism had been abandoned by all but a tenacious few. Behviorism was moving toward its position of dominance in American psychology, Gestalt psychology held sway in Germany, the center of European psychology; and Psychoanalytic theory was beginning to be seriously considered by some American academic psychologists. But in spite of its disappearance as a school of psychology, Structuralism lived on in a number of ways.

The most vital part of the structuralist program was psychophysics, the study of the relation between variation in the intensities of physical stimuli and variations in the magnitudes of the experiences elicited by these stimuli. The study of psychophysics, the very first topic in experimental psychology, continues today. Psychologists are still busy measuring sensory thresholds, which are (very loosely speaking) the minimum amounts of energy stimuli must have in order to be experienced. The methods used today in psychophysical studies are direct descendants of the ones invented by the structuralists. The psychophysical findings of the psychologists of the 19th century continue to be of use.

Not only do modern psychophysicists measure thresholds as their predecessors did, they also are concerned with describing the dimensions along which experiences of stimuli can be located. However, unlike their forebearers, modern psychophysicists regard their dimensions as analytic abstractions imposed upon the complex stuff of experience. They do not require their dimensions to correspond to some known physiological process; instead their criteria are purely behavioral. The liberation from the constraints imposed by an _a priori_ physiological model has permitted the extension of dimensional analysis, known as scaling, to much more complex experiences. Techniques have been derived for scaling the intensities of attitudes, the desirability of various necktie designs, and some aspects of the meanings of words, etc. Surprising as it may seem the social psychologist who constructs a scale to measure attitudes toward war or the location of words of various dimensions of meaning, is carrying on work which makes use of techniques and concepts invented by men who believed that experience had to be purged of meaning before it could be subjected to scientific study. We will have much more to say about psychophysics later in the semester.

Today work also continues along lines that would have warmed the heart of Titchner, even though he would not have considred it psychology. Advances in technology have made it possible to study the physiology of the sensory receptors and related central nervous system processes in amazing detail. Physiologists and physiological psychologists can now describe many relationships between experience as measured by psychophysical methods and physiological processes. The processes are much more complicated than was suspected in Titchner's time and do not lend themselves to the atomistic, switchboard conception he preferred. Nevertheless, if it weren't for the careful psychophysical work of the structuralists and those who followed them, the relation between physiological processes and simple sensory experiences would have remained opaque to the light of inquiry. As has frequently been the case in this century, the careful study of behavioral regularities preceded and either directly stimulated or at least facilitated the study of corresponding physiological processes.

## Introduction to Gestalt Psychology

For the most part we can let Gestalt psychology be introduced by Wolfgang Köhler, the most prolific of the triumvirate (Wertheimer, Koffka and Köhler) which founded the gestalt movement. Köhler is a 20th century man. He had graduate training in physics before he entered psychology and it is clear that his psychological concepts owe much to his early contact with the queen of the sciences. If structuralism could be called mental chemistry because of its stress on elements and their combination into mental compounds, gestalt psychology could be called mental physics because of its reliance upon concepts such as vectors, steady states, fields, etc. The dynamic flavor (dealing with forces and energy) of gestalt psychology has much in common with psychoanalysis and one thinks that the two ought to have easily joined forces against the old order of structuralism and the new order of behaviorism, but they didn't except in the works of J. F. Brown.

Because the physicalistic, dynamic concepts of gestalt psychology are unusual and very important, it is wise to look at them closely before you plunge into your readings in Köhler. There are two levels at which these concepts can be treated. One is at the level of purely hypothetical psychological forces which affect perception and behavior; the other is at the level of equally hypothetical physiochemical forces at play in the brain cortex. As one might expect, the two are closely related. For the present, we shall confine ourselves to the abstract psychological forces.

A force may be thought of as that which can produce motion or change. Psychological forces are those which can produce change either in overt behavior or in experience. Although gestalt psychology was concerned with behavior as well as experience it was most highly developed with regard to the latter and it is the latter which will concern us. Forces have two aspects, strength and direction. Whether a given force will actually result in some kind of change depends upon the strengths and directions of other forces operating upon the same point as the first.

All of us have an intuitive understanding of the concept of force as it is applied to the movements of physical matter in our immediate environment. We know about the muscle force it takes to lift objects. We know that it takes more muscle force to lift heavy objects than light ones. This last bit of knowledge can be rephrased to state that the amount of force required to lift an object is proportional to the force of gravity exerted upon the object. We also know that the amount of muscle force depends upon the angle our path of lift makes with respect to the angle at which the force of gravity is exerted. We know that it is easier to lift an object under water than in the atmosphere because of the buoyant force exerted on the volume of water displaced by the object we are lifting.

The buoyant force is itself a function of gravity. We know that some objects can float because the gravitational force exerted on them is less than the gravitational force exerted on an equal volume of water. We know that a floating object sinks far enough to displace an amount of water which is equal to it in weight. At this point the gravitational force exerted on the object is balanced by the buoyant force exerted by the water. If we exert a force on the object which is sufficient to push it beneath the water and then release our hold, the object pops back up and after a few moments of bobbing comes to rest again at the same degree of submersion as before, thereby reestablishing the previous equilibrium.

Although we may never have had more than high school physics, we can understand the operation of the gravity, despite its abstractness. A more difficult kind of force concept to understand, but one which comes closer to the concept used by the gestaltists is electromagnetic force. Like gravity, electromagnetic force is not exerted only at single points, rather it pervades large areas called fields. At any point in the area, the force has a given strength and direction. Most of us have seen the demonstration in which the field nature of magnetic forces is illustrated by placing a bar magnet beneath a sheet of glass and then sprinkling iron filings on the glass. The filings are distributed over the glass in a pattern determined by the magnetic field. The major restriction to this movement is the friction (also a force) between the glass and the filings.

So far our examples have included closed systems, systems in which the amount of energy or matter available is constant; the only exception to this was the intrusion of a heavy hand upon our floating object. There are also open systems, ones in which there is a continuous input and output of energy or matter. The system of forces affecting the water in a decorative fountain is an open system because new water is continuously being shot into the air. The weather system over a continent is an open system, the currents in an ocean constitute an open system. There are undoubtedly electromagnetic open systems unknown to those, such as myself, who are uninitiated into the mysteries of physics. Despite the fact that such systems are open, they are not necessarily irregular.

All the examples just mentioned exhibit more or less regularity in the way in which matter passes through them. In the case of a water fountain, the pattern of the regularity is easily discerned. Recently, the use of weather satellites has allowed us to literally see patterns in weather systems which before had to be pieced together from scattered reports of air pressure, wind direction and velocity, temperature and precipitation. Ocean currents are probably better examples than weather of open systems which exhibit a regular pattern despite constant change in the substance of which the pattern is created. Such a stable pattern has been called a "steady state" by Köhler, who wishes to distinguish it from the state of equilibrium. In the latter there is no motion because the forces at work counteract each other and no new forces are added. In the steady state there is constant change, but it takes place in a regular pattern because of the interplay of forces. Despite the apparent usefulness of the distinction between steady states and states of equilibrium, most gestalt psychologists do not use the two terms differently. This causes no confusion, however, because almost all the situations to which the labels are applied involve open systems and hence steady states. In the face of this fact, psychologists have perversely shown a preference for the term equilibrium.

The only other term in the set we are considering, which requires definition is system; this is a set of parts arranged so that changes in any one part have effects on the other parts. Clearly, force fields are systems. It is assumed that all systems tend toward equilibria or steady states. The exact process through which this tendency works varies with the system being considered, but as an abstract principle, it applies to all systems. Note that the assumption holds that systems tend toward equilibria but does not hold that they necessarily reach equilibria. Whether they do or not depends upon the conditions under which the system is operating.

The preceding discussion of general terms was meant to give you an intuitive grasp of the framework within which the gestalists approached the study of psychology. The use of such concepts as force and field probably seem as peculiar to you now as they did when they were first disseminated among psychologists in the second decade of this century. They do not fit the atomistic, associationist mode of thinking about human mental life, which mold is the common heritage of western man. In what follows, an attempt will be made to show how these general theoretical terms are used in the gestalt theory of perception. The discussion will be limited to a consideration of the psychological aspects of the theory. The physiological aspects will be treated later. Although the gestaltists intend their theory to cover all aspects of perception it has been applied most successfully to the perception of visual shapes and forms. It would be well, therefore, to keep the visual experience of the shapes of figures in mind as the major outlines of gestalt theory are described.

The perceptual field is an open system, with short lived energy inputs from the sensory receptors. The flow of energy in the field is determined by the forces acting upon the part of the field in which the energy is located. The organization or pattern of experience is produced by the organization or pattern of energy flow in the perceptual field. The term perceptual field is, unfortunately, used ambiguously by gestaltists. Sometimes it refers to the hypothetical field in which forces shape the distribution of the sensory input energy. This is how the term is used here. However at times it is also used to refer to the experience resulting from the operation of forces in the hypothetical field. It is usually possible to differentiate the two by paying attention to how they are used, but sometimes the impression is given that we are directly aware of the operation of forces at play in the perceptual field. This is not what the gestaltists believe. Our experience depends upon these forces and allows us to infer the characteristics of the forces, but it does not give us direct awareness of them.

The distribution of energy flow in the field at any time is a function of three factors: (a) the distribution of sensory input, e.g. the spatial array of stimulation received via the visual input channel, (b) the state of the field into which the input is fed, and (c) the operation of the tendency toward steady states, characteristic of all open systems. In the perceptual field the tendency toward balance and steady states is called the Law of Prägnanz. This law asserts that the energy flow in the perceptual field will be as regular and symmetrical as possible, given the distribution of the sensory input and the state of the field at the time. Since perceptual experience, particularly in its formal aspects, is a direct function of the flow of energy, the Law of Prägnanz means that our perceptual experience will be organized as symmetrically and regularly as possible, given the nature of the stimuli impinging upon our sensory receptors and our perceptual state at the time.

Energy flows in the perceptual field as electricity flows in some solid mass of conducting material. That is, it flows from areas of greater concentration to areas of lesser concentration. If energy is evenly distributed over the entire perceptual field, there will be no flow in the field and therefore no visual experience. There must be some inhomogeneity in the sensory energy reaching the field in order to produce the energy flows upon which visual experience depends. As we have mentioned the strength and direction of the flow depends in the first instance upon the distribution of sensory input. More specifically it is the relations among the amounts of energy in the various parts of the field that determines the strength and direction of the flow and therefore the intensity and form of the visual experience. It is in this sense that visual, as well as all other kinds of experiences, are said to be relationally determined.

The relational determination of perception was a revolutionary concept. The structuralists had held that our sensory experience is merely the sum of the stimulation of our sensory receptors and of the cortical cells which are perfectly correlated with them. The nature of a sensory experience was said to depend upon the locus and characteristics of the specific cells stimulated. To be sure, perceptual experience depended upon relations between these discrete sensory processes and memories, but the immediate unelaborated experience was a mosaic, each part of which was independent of all other parts. While the gestaltists admitted that the sensory input to the perceptual field was indeed the kind of mosaic described by the structuralists, they asserted that it was the relations among

40

the parts of the mosaic, that is the forces set up by the inhomogeneities among the parts of the mosaic, which determined the experience.

The controversy over determination of experience by points or by relations among points leads to an interesting experimental confrontation of the two theories. Suppose we were to expose a person to a completely homogeneous, deeply saturated, colored environmental field. In such a case the structuralists would predict an experience in which a person sees a two dimensional surface (there being no cues to elicit the associations necessary for the perception of depth) which was colored with the hue of the light reflected from the environment. This sounds like quite a reasonable prediction. The gestaltists would predict that despite its hue, the stimulus should yield the perception of a three dimensional neutral grey void. They would admit to some color at the outset due to the inhomogeneity between the current input and traces of the immediately preceding input, but they would expect this color to fade quickly. You will be reading about and experiencing the outcome of this confrontation between the structuralist and gestalt predictions.

We have seen that in order to perceive something other than a void the gestaltists hold that there must be some inhomegeneity in the input to the perceptual field, which in the normal organism means some inhomogeneity in the stimulation falling upon the sensory receptors. This is a condition which is very easily met, indeed its opposite is extremely difficult to achieve. The next factor mentioned as a determinant of perception was the state of the perceptual field. There are two aspects of this state which have been discussed by the gestalt theorists. The first is an inherent directionality. They claim that the field has a built in top, bottom, right and left and that the identical input will give rise to a different perceptual experience depending upon its orientation with respect to these built in directions. The example usually given in this connection is that of a figure with four equally long straight sides, which meet at 90 degree corners. When such a figure is exposed so that the input from its sides are parallel with the vertical and horizontal directions of the perceptual field, or bear some relationship which is topologically equivalent to parallel, the figure is seen as a square. When it is oriented so that the inputs from the corners are aligned along the major axes of the field, it is seen as an entirely different figure, a diamond. The reason for this is not found in the nature of energy currents; the directionality of the field and its effects on the corresponding energy currents in it are to be accepted as unexplainable givens. Though this seems troublesome it has not proved so, primarily because it has not been studied very intensively. We shall have occasion to return to the issue later in the semester.

The second characteristic of the field which affects experience is one that does influence the figural currents in the field. It is the amount of resistance to the flow of energy in a given area of the field. The major determinant of such resistance is the previous flow of energy through the same area. As in the case of the flow of electrical energy, figural currents will be directed so that they flow through the areas offering the least resistance in the vicinity of their path. This means that two identical inputs to areas with different degrees and patterns of resistance will produce different energy flows and hence different experiences. Much more will be said of this later in connection with the study of figural aftereffects.

The final determinants of experience are the tendencies referred to by the Law of Prägnanz. The Law of Prägnanz operates in either of two ways to achieve the goal of maximum regularity. The first is by eliminating inhomogeneities. In a closed system this is the primary way of achieving balance; all the energy is evenly distributed. But in open systems such as the perceptual field, uniformity is difficult to accomplish because of the continuous input of inhomogeneously distributed energy. Hence a second method is used for achieving regularity, namely the creation or accentuation of boundaries between inhomogeneous areas.

A homely example may serve to illuminate the difference between the two ways of achieving stability. Think of a steaming bowl of chicken soup with golden globules of fat floating on the surface. Concentrate on a nice large globule and imagine performing the following operations. Take a toothpick and dip the point into the globule near its boundary. Then draw the toothpick slowly away from the center of the globule. When the globule has assumed a rough hourglass shape, withdraw the toothpick carefully and observe. Either of two things will happen. The areas at the ends of the hourglass shape will begin to draw together until the globule regains its original spherical shape. Or the two ends will appear to pull on the portion connecting them until it breaks and each of them assumes a spherical shape. In either case, once the spherical shape is achieved, it remains stable, barring any further outside disturbances. In one case the stability was achieved by eliminating the irregularity in the surface of the globule. In the other it was attained by accentuating the irregularity until it became a boundary between two parts.

It is not clear how the creation or accentuation of boundaries produces a steady state in the perceptual field. Perhaps they create barriers to the flow of energy so that separate currents flow within and around boundaries without disturbing currents on the other side. Uniformity may then be possible within bounded areas. With complex stimuli, the unorganized flow of currents in the entire field would never lead to uniformity because of the constant input of inhomogeneous energy, therefore uniformity within bounded areas is the most stable organization possible. We need only consider the effects of improper focus or severe disturbances of bodily equilibrium to realize how unstable experienced visual fields become when clear boundaries are absent. In any event, we should be prepared to see the effects of both modes of operation of the Law of

Prägnanz. The stronger and more differentiated the input, the more we should expect the boundary-creating mode to be dominant.

The preceding long exposition of some of the basic concepts of gestalt psychology is misleading in that it conjures up images of psychologists leaning back in their armchairs or hunched over their typewriters spinning out awfully tenuous speculation about the determinants of perception. Although they were quite theoretical and even philosophical, the gestalt psychologists were also avid data collectors. A large part of their program was directed at describing visual experience with emphasis on its organizational characteristics. There were no _a priori_ limits on what could be observed and as a result a number of new perceptual phenomena were discovered. They were most happy when they could discover experiences which departed from literal representations of stimuli in the direction of being more organized, regular, etc. They were also happy to be able to find instances in which the formal characteristics of stimuli outweighed the effects of past experience in determining perceptual experience.

Much gestalt research did not take the form of experiments in which conditions were varied and predictions were made about the outcome. Often they worked on the construction of demonstrations which illustrated the operation of the Law of Prägnanz or of the many sub-laws into which it was broken. Most of the work was non-quantitative although some was highly quantitative. There is hardly an area in the study of visual perception which has not been examined by some gestalt psychologist. Much of our knowledge of visual perception is the outcome of gestalt oriented research.

The movement was at its peak during the 1920's. The advent of the Nazis led many gestalt psychologists to leave Germany for America and eliminated many others. Although the leaders of the movement continued to write and teach in America, they were so out of keeping with the dominant behaviorst orientation here that they failed to really propagate themselves via graduate students. None of them had positions at major Universities. Most influential was Köhler who taught at Swarthmore. He was able to train some graduate students. Koffka taught at Smith and except for his definitive work of Gestalt Psychology (the most detailed and scholarly comprehensive book produced by the movement), he had little success in America and died a few years after arriving. Wertheimer taught at the New School in New York City and did train a few outstanding psychologists.

Surprisingly, it was in the field of social psychology that the gestalt movement had its greatest success in America. Kurt Lewin, who was trained by the illustrious trio soon after the beginning of the movement, gave a lasting gestalt and perceptual orientation to much of American social psychology. Lewin died suddenly just as his work was beginning to get the attention it deserved.

Now that we have completed this cursory introduction to gestalt theory, we can turn to the rich world of perceptual experience to develop the themes that have been outlined here. Most of this section will consist of reading and viewing gestalt demonstrations and experiments. It will be up to you to relate them to the theoretical outline presented here and to thereby simultaneously increase your understanding of perception and gestalt theory.

# Testing Gestalt Theory Concerning the Dynamic Effects of Shape

The best starting point for this discussion is an examination of the term, "dynamic effects of shape." We have already seen that "dynamic" refers to the action of perceptual forces which are responsible for the organization of the sensory input. These forces are always at work, but they are most convincingly demonstrated when they bring about organizations which depart from what we would naively expect on the basis of what we know of the sensory input. Such demonstrations make up the greater part of the Gestalt research on the dynamic effects of shape.

A frequent class of such demonstrations compares the perception of identical local stimuli (see Köhler's Gestalt Psychology, Chap. 3, for definition of this term) situated in different figural contexts. The local stimulus inputs are said to be perceived differently as a consequence of being subjected to the dissimilar forces characterizing the different figures. Fuchs' transparancy and assimilation demonstrations belong in this class.

Another type of demonstration focuses on some differences in the perception of figures themselves as a consequence of differences in the strength of forces which give rise to them. Generally, good figures, i.e., ones which arise from strong forces, are compared with figures arising from weak forces, holding the physical intensities of the relevant stimulus inputs constant. It has been reported that good figures have lower thresholds, lower critical flicker fusion frequencies and are more likely to be dominant in binocular rivalry than bad figures. Good figures are also supposed to produce longer lasting afterimages and to be more resistant to disruption by other stimulus inputs. The comparison of the dynamic effects of figure and ground also belong in this class because the ground can be thought of as being characterized by extremely low or nil strength of figure producing forces.

Many of the demonstrations of the dynamic effects of shape were performed in Germany during the second and third decades of this century. The reports describing them are not readily accessible so that it is difficult to evaluate their methodological adequacy. Current attempts at demonstrating the effects are not always successful, sometimes because of the operation of extraneous variables, which are difficult to control and sometimes because of apparant shortcomings in the theory itself. Examination of these failures, some of which are drawn from student projects in this course, is instructive and will constitute the major part of these notes.

A number of students have attempted to show that a spot must be exposed for a longer time if it is to be perceived when flashed on a figure than when flashed on a ground area. This "simple" demonstration involves a distressing number of pitfalls which either invalidate apparantly positive results or prevent such results from being obtained. One student compared the duration thresholds for a black dot projected inside or outside an outline circle. He had his *S*s fixate the center of the circle while he flashed the dots either inside or outside the circle for varying lengths of time. He found a lower threshold within the circle than outside. However, his results cannot be taken as evidence against the theory because he did not control for differences in visual acuity at the center and periphery of the visual field.

Another student, climbing upon the vanquished form of the first, decided to use an iron cross embedded in a circle (Fig. 1) as his stimulus. He flashed dots in the a and b positions indicated in Fig. 1 and did obtain the expected result. However, when he rotated the figure so that the arms were diagonal he found the opposite results. It seems as if his *S*s were just more accurate with dots located along the central vertical and horizontal axes of their perceptual fields than they were with dots along the diagonal axis.

Fig. 1

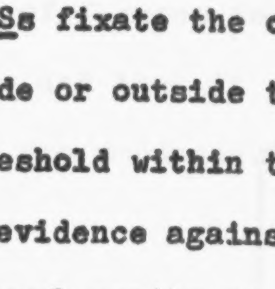
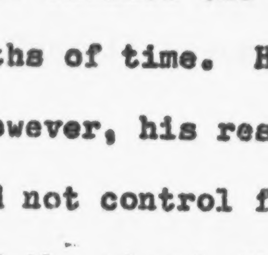


Fig. 2



Also drawn by the fatal lure of this "simple" demonstration, another student used the stimulus shown in Fig. 2, with dots projected at a or b. Ss were given some preliminary practice in reversing the figure and ground in their perceptions of the stimulus and were supposed to have been brought to the point where they could see the pattern either way, at will. This design controlled the two bothersome variables which had interfered with previous attempts; however, it ran into its own difficulty. Ss were not reliable in their perceptions of figure and ground. They did not always follow the Es instruction to see the figure in a particular way and at times they were unable to report which part of the stimulus was seen as figure. Another difficulty was that some Ss said that on some trials they saw neigher part of the figure as pattern. Instead they concentrated on the region in which the dots appeared and ignored the rest of the stimulus. Although it is tempting to blame the foregoing failures on novice Es and stupid, weak-willed Ss, it must be granted that the phenomenon of differential thresholds inside and outside of figures is considerably less obvious than would appear at first glance and that it cannot lend much support to Gestalt theory until better data are produced.

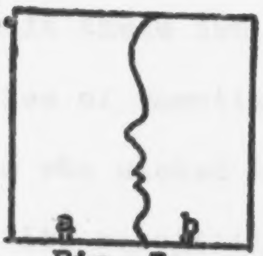


Fig. 3

Turning to published research on the dynamic effects of shape we find a study by Weitzman in the *Journal of Experimental Psychology*, 1963, Vol. 66, pp. 201-205. Weitzman used stimulus in Fig. 3. Sometimes the face was oriented toward the left and sometimes toward the right. The stimuli were presented tachistoscopically and Ss were asked to describe what they saw as accurately as possible. On some exposure a small gap appeared at point a in the contour, in others point b. Weitzman wanted to know if the gap would be more readily seen when it was at the bottom of the facial area or when it was at the bottom of the ground. He found that the gap was noted more readily when it was at the bottom of the area inside the facial contour. He claimed that this follows from Gestalt theory because the theory says that the figural process is stronger in the facial area. To be sure this is what the theory does say, but one could as easily expect the opposite result on the basis of the same premise. The stronger process should fill in the gap so that the gap should have a higher threshold when under the facial area. To make matters even cloudier, it is not clear whether the bottom boundary should be considered part of a face figure. The square contour seems to bound the entire area rather than just the area inside the facial contour. Gestalt theory gives no clear directions on how to decide whether a contour belongs to a figure or not. Perceptual belongingness is assessed intuitively and although this is adequate in many cases, it doesn't help in the present one. A good theory should not allow contradictory derivations from the same set or propositions and conditions; it should also suggest clear tests of whether a given proposition is relevant to a specific case. Gestalt theory frequently falls short of the mark in these two respects.

Continuing our review of unsatisfactory research we come to a project designed by two students who wished to test the hypothesis that the better a figure was, the lower its recognition threshold would be. Earlier researchers had reported such results. The students used seven figures cut from black paper and mounted on a white background. The shapes of the figures were: square, pentagon, hexagon, decagon, "fourtennagon" (our students were clearly not lovers of the English language) and circle. These were exposed one at a time in random order for three seconds. Following an opportunity to familiarize themselves with the figures, the Ss were asked to identify the figure shown on each exposure. According to Gestalt theory, the circle is the best figure of the lot, primarily because of its simplicity and continuity. The circle, therefore should have been identified correctly most often. The theory also leads us to expect that errors in identification should be in the direction of labeling the figures as more circle-like than they actually were. This should be so because of the operation of the Law of Prägnanz, which operation should be enhanced by the dim illumination.

Despite their confidence and the apparant clarity of the Gestalt position in this area, the student researchers did not find what they expected. The square was recognized most accurately while the circle was next to last in recognition accuracy. Furthermore, errors did not consist of figures being identified as more circle-like than they actually were. Instead, errors consisted of displacements toward the center of the series of seven figures. In an insightful discussion of their results, the researchers pointed to two possible determinants of their results. First they noted that the ease of identification of a stimulus depends not only on the properties of the stimulus itself, but also upon its similarity to the stimuli from which it is being discriminated. In this respect, the square was undoubtedly the easiest figure because it was the most distinctive. The remaining figures were more similar to each other than they were to the square, especially as one moved toward the circle end of the set. Secondly, they observed that their Ss may not have attempted to recognize the figures as wholes, but rather may have tried to find specific parts of the figures which would serve as reliable clues yo their identities. Some Ss, for example, reported counting the number of angles in the figures. Clearly the fewer the angles, the easier it was to identify a stimulus by this method, hence the greater accuracy of the square and the inferior accuracy of the "fourteenagon." However successful this strategy might have proved, it destroyed the relevance of the task to Gestalt Psychology. The figures must be reacted to as unanalyzed wholes in order for the theory to be applicable. Where attention is confined to single parts of a figure, one should not expect the creation of the kind of force fields which the theory holds responsible for the dynamic effects of shape. As we have noted above, the theory doesn't say much about the determinants of the failure to see patterns as wholes. Indeed, it is difficult to see how such failures are possible in the perceptual system described by the Gestaltists. Köhler dismisses such analytic experiences as atypical, and artificially produced by the special analytic introspectionist attitude. While he may be correct in his description, he is still obligated to tell us how the special attitude produces its artificial results.

A group of investigators at Cornell obtained data similar to ones just described (Krauskopf, Dureyea and Bitterman, *American Journal of Psychology*, 1954, Vol. *67*, pp. 427-440.) Their *S*s were asked to identify the following symbols: L, +, X, and T. They found that the thresholds for the symbols decreased as the lengths of the arms increased. They concluded that two variables were related to ease of form recognition. The first was the area of the form and the second, more important one, was the ratio of the perimeter of the form to its area. When the ratio is large, it means that there is much critical detail, e.g., long arms, which aid in figure recognition. An earlier experiment by this group found that when *S*s did not know beforehand the figures they were to see, but simply described what they saw, the responses tended to conform to what was expected on the basis of Gestalt theory, e.g., errors were in the direction of making figures look more like circles than was actually the case.

The studies of figure recognition suggest that one should not think of *S*s passively experiencing and then identifying figures. Rather one should conceive of *S*s actively seeking the information they need to solve the problems set for them by *E*s. Different problems probably lead to different strategies of processing information and these differences may be responsible for variation in the success of Gestalt predictions concerning figure recognition.

The final study to be discussed was also done by a student. Once again the hypothesis concerned the greater recognizability of good figures. The task pitted figures, which varyied in symmetry against one another in a stereoscope, with the expectation that the better the figure was, the more dominant it should be in the binocular rivalry. The figures were constructed after a method described by Attneave (Psychological Review, 1954, Vol. 61, pp. 183-193.) The method involves blacking in the cells of a grid in a systematic way. The student researcher divided his grid into four equal quadrants and measured the degree of symmetry of his patterns counting the number of filled cells which overlapped when one quadrant was reflected into its neighboring vertical or horizontal quadrant. The reflection was accomplished by folding the paper along the lines separating the quadrants. The second part of his experiment employed a guessing procedure in which subjects were given blank grids and were asked to guess the pattern on the E's grid. Ss proceeded across the grid one row at a time, guessing whether or not each cell was filled. E informed them of the correctness of their guesses and kept records of the number and location of errors. It was expected that the more symmetrical the figure, the fewer errors there would be.

The results of the experiment were surprising. When the figures were ranked in order of the number of errors made on them during the guessing game, the resulting order was the one predicted, with the fewest errors made on the most symmetrical figures. However, the order of the figures with respect to dominance was just the reverse of what was expected. The most dominant figure was the one with the least symmetry.

Having an extremely high verbal ACE score, the student quickly constructed an after the fact explanation of his results. He too took a problem solving point of view toward the experimental situations he used. The application of this view to the guessing game leads us to expect that once the subjects realized that they were guessing a symmetrical figure, their errors would disappear. An examination of the data did reveal sharp declines in the number of errors with the relatively symmetrical figures as the Ss progressed through the grid. It also revealed that the errors tended to be restricted to cells in which figures departed from symmetry. In other words, the assumption of symmetry allowed Ss to predict the parts of the figure they did not yet know; when the assumption was justified, their predictions were correct. They needed less information to solve the problem of specifying the shape as the shapes became more symmetrical. In the case of the binocular rivalry task, Ss also needed less information to discover the shapes of the symmetrical figures, hence, they spent less time looking at these than at the less symmetrical ones. To be sure, they didn't consciously force one figure to be dominant over the other. Instead, we must assume that the perceptual system automatically tended to give higher priority to inputs which were uncertain than to those which have been definitely identified. Despite the anthropomorphic ring to this view, it is consistent with what we know about the tendency of the nervous system to react more actively to novel rather than familiar inputs. It is also consistent with the modern neurophysiological theorizing discussed earlier this semester.

The conclusion of this tale of experimental failure is not that the Gestalt views of the dynamic effects of shape are useless; clearly sometimes things occur in accordance with the theory. Rather we must recognize that introspection in the Gestalt style is only one of several possible perceptual tasks. The perceptual processes called into play may differ from one general type of task to another. To borrow from physics, the Gestalt laws may have much of the status (although little of the rigor) of Newton's laws. They may be important special cases awaiting a general theory which will encompass them and together with the perceptual laws which apply to other classes of perceptual tasks. Perception's Einstein has yet to appear.

## The Quantitative Study of Form

The tendency to organize the perceptual field so as to achieve good figures, is of paramount importance in the gestalt approach to perception. Most of the demonstrations we have encountered thus far illustrate the operation of this tendency, i.e., The Law of Prägnanz, in one form or another. One might expect that the importance of the principle would have led the gestaltists to devote a great deal of effort to constructing a precise definition for it and to creating operations to measure variations in forms along the dimension of figural goodness. However, this has not occurred. Apart from Kurt Lewin, who tried to use topological constructs to describe psychological concepts, the gestaltists have been relatively uninterested in formalizing their approach.

The major reasons for the relative scarcity of quantitative concepts in Gestalt Psychology were the lack of understanding of the phenomena studied and the lack of mathematical models or lack of knowledge of mathematical models which were appropriate to the representation of gestalt concepts. The gestaltists believed that premature formalization would limit the development of their approach and perhaps shut out fruitful areas of inquiry. At the time of the founding of the school the only examples of formal mathematical models in psychology occurred in psychophysics. The gestaltists thought that the psychophysical models obscured rather than clarified the essential quality of experience, namely its organization. The increase in both knowledge of perception and mathematical sophistication in psychology has led some psychologists to try to quantify the elusive concept of good figure and more generally to develop quantitative measures of visual forms.

According to the gestaltists, good figures are ones which are closed, regular, symmetrical, and continuous. One of the easiest questions to ask about this definition is whether the properties specified by the gestaltists are actually the ones naive subjects consider good? A doctoral dissertation done by Marian Mowatt at Bryn Mawr during the early twenties attempted to answer this question. She presented her subjects with a variety of outline drawings of figures and asked them to change the figures to make them good figures, if such changes appeared to be needed. (See page 173 of B and W for the figures she used.) She then examined which figures were changed least and what kinds of changes were made in the figures that were altered. Some of her findings were:

a) 72 percent of her subjects left the outline circle unchanged. Corresponding percentages for other figures were: isoceles triangle - 70 percent, hexagon - 62 percent, rectangle - 62 percent, square - 60 percent.

b) 61 percent of the changes enhanced the closure of the figures:, 2 percent decreased it.

c) 38 percent of changes increased symmetry; 17 percent decreased it.

d) 20 - 30 percent of the figures, depending upon type, were changed to increase continuity. Mowatt found very few cases in which changes substantially reduced continuity.

e) Five times as many familiar"bad" figures were changed to unfamiliar good figures than were unfamiliar good figures changed to familiar "bad" figures.

Mowatt's study was consistent with the view that the gestaltists did not depart from their naive, unpsychological brethren in their specification of what figures were to be considered good.

Despite its agreement with gestalt theory, Mowatt's study is not too impressive. The fact that gestalt psychologists and Bryn Mawr undergraduates agree in their definitions of good figures is no guarantee that these definitions are theoretically sound. A much more impressive demonstration would predict specific consequences of variations in figural goodness and then show that these consequences did indeed occur as the symmetry, closedness, etc. of figures varied. The article by Hochberg and McAlister uses this type of criterion. They predict that when subjects are shown figures which can be seen as possessing two shapes, they ought to see the better shape more frequently than the other. All of the recent investigations of figural goodness have used the ability to predict variations in perceptions of shapes as the criterion for determining whether or not a given property is a determinant of figural goodness.

Recent studies have also substituted quantitative for qualitative descriptions of good figures. Most of the quantitative measures focus on the informational properties of the stimulus. Figures which require less information to describe them are said to be better figures than ones which require more information. The article by Hochberg and McAlister uses a fairly simple-minded measure of information. Other researchers have made use of a branch of probability theory known as information theory to make more precise specifications of the amount of information necessary to describe a figure, or more accurately to select it from a given array of alternatives.

Quantitative techniques have also been created for generating figures with known amounts of information. Information theory can be applied to auditory configurations as well as to visual ones. Indeed, information theory was first developed by telephone engineers who were concerned with measuring the amount of information contained in auditory signals. No attempt will be made to describe information theory here, but interested students can find an excellent introduction in a book by Fred Attneave, entitled, Applications of Information Theory to Psychology.

Unfortunately, the more use researchers make of information theory, the less they study phenomena of interest to the gestaltists. Their problems are selected more in terms of what is relevant to information theory than in terms of already existing theoretical questions. While this enriches our knowledge of perception, it still leaves the earlier theoretical questions unanswered. It is likely, however, that the rapid increase in the use of mathematics in psychology will bring us to the point where the mathematics becomes relevant to a wide variety of problems.

## Some Comments on Threshold Theories

### Alternative conceptions of the detection process

Common sense. For the sake of argument, let us postulate a completely unsophisticated straw man whom we shall demolish with a single stroke. When asked for his detection model, our everyman would reply that there is absolute threshold which is relatively constant and also a sensory process, whose strength is a function of the intensity of the physical stimulus impinging upon the sensory receptor, wherein the sensory process originates. According to this model a stimulus of a given intensity either is above or below the threshold. If it is above, it will be experienced and reported as present; if it is below it will not be experienced and will be reported as absent. Repetition of the same stimulus to the same observer would always lead to the same report. If it didn't, this was because the observer was lying or inattentive. In either case the variation in the report of an observer to repeated presentations of the same stimulus would be attributed to some error which was extraneous to the detection process. Put concisely, common sense would say that detection is a function of the relation between a fixed stimulus effect, a fixed threshold and a variable error. According to this model, one should be able to purge the error from the observation process and then rely upon detection reports as direct reflections of an observer's experiences.

This is quite a reasonable model; unfortunately it has difficulty with the fact that highly trained, highly motivated, very honest observers vary in their detection reports when a given stimulus is presented more than once. At this point, everyman throws up his hands and bemoans the imperfectibility of human nature and the inevitability of error in human information processing. Although such an approach obviates the necessity for studying variability, in detection reports to repetitions of a constant stimulus, thereby leaving time for the finer things in life, it does not enlighten us about the detection process.

The classical approach. The view of detection which was generally accepted by psychologists from the start of scientific psychology until the late 1940's was that the threshold varied from moment to moment and that the sensory process elicited by a given stimulus intensity was always the same. This is the view that is given in most psychology texts, where a normal curve is used to describe the distribution of threshold values over time. This is also the view that provides the rationale for defining the detection threshold as the stimulus value which is reported correctly 50% of the time.

Latter day psychophysicists, such as Blackwell, have elaborated upon this model by adding a non-sensory, guessing factor to the determinants of the perceptual report. This is the approach taken in Dember's discussion. Blackwell's model may be described by the following equation:

$$p_1 = p_1' + p_o \ (1 - p_1')$$

where $p_1$ = the observed proportion of yes responses,
$p_1'$ = the true proportion of yes responses, i.e., hits, and
$p_o$ = the probability of false positive responses, i.e.,the probability of saying yes when the sensory process is below the momentary threshold.

According to this theory, false positives are due to lucky guesses. The task of the experimenter is to determine the true proportion of yes responses, ( $p_1'$ ) to each stimulus and then determine, by interpolation if necessary, the stimulus value that would elicit hits 50% of the time. To do this, he must correct the observed proportion of yes responses in order to get rid of the false positives. The corrected or true proportion of yes responses can be obtained by solving Blackwell's equation for $p_1'$, as follows:

$$p_1 = p_1' + p_o - p_1' p_o$$

$$p_1 - p_o = p_1' - p_1' p_o$$

$$p_1 - p_o = p_1' \ (1 - p_o)$$

$$\frac{p_1 - p_o}{1 - p_o} = p_1'$$

When using a yes-no response, $p_o$ is estimated by the proportion of yes responses given on catch trials, i e., ones on which no stimulus is presented. With the forced choice procedure, $p_o$ is given an a priori value based on the number of alternatives from which the observer must select his response. When each alternative is correct equally often and other things are equal, $p_o$ = 1/no. alternatives.

The missing variants. Although no one has proposed them one might conceive of models in which the threshold was constant and the sensory processes, elicited by repeated presentations of a constant stimulus, varied. One might also conceive of a model in which both thresholds and sensory processes, elicited by constant stimuli, varied. The low threshold theory alluded to by Swets may be of the former type.

The decision theory of detection. In 1954 Swets, Tanner and Birdsall, of the University of Michigan, put forth a statistical decision theory of detection. Their theory was rather revolutionary in that it dispensed entirely with the threshold concept. Instead it postulated that observers were sensitive to any sensory process, however faint it might be. It also postulated that sensory processes could be activated spontaneously, i.e., without a stimulus or signal being presented to the observer. These spontaneous sensory processes were called noise. Noise was said to vary in intensity over time, with its frequency distribution assuming the shape of the normal curve. For the sake of simplicity, they assumed that a signal of constant physical magnitude added a constant intensity to the varying sensory intensity produced by noise alone. It follows from this assumption that the distribution of sensory processes due to signal added to noise would also be normal in shape, and that the mean of the signal plus noise distribution (SN) would be more intense than the mean of the noise distribution (N) by an amount equal to the intensity contributed by the signal to the sensory process.

For Swets, et al., the detection process, using a yes-no response, was one in which the observer had to decide whether a given sensory event was due to a signal superimposed upon the noise background or just plain noise. Put somewhat differently, the observer had to decide whether an event with the intensity of the one in question was more likely to have occurred from noise alone or from a signal superimposed upon noise. To make this decision the observer relies upon his "knowledge" of the heights of the N and SN distributions at the sensory intensity in question. Other things being equal, if the N distribution is higher than the SN distribution at the point in question, he would decide to report that no signal had been presented; if the opposite were true he would make the opposite decision. Fig. 1 presents a situation in which the observer would decide that no signal was presented when given sensory event of intensity x and would make the opposite decision for a sensory event at intensity z.

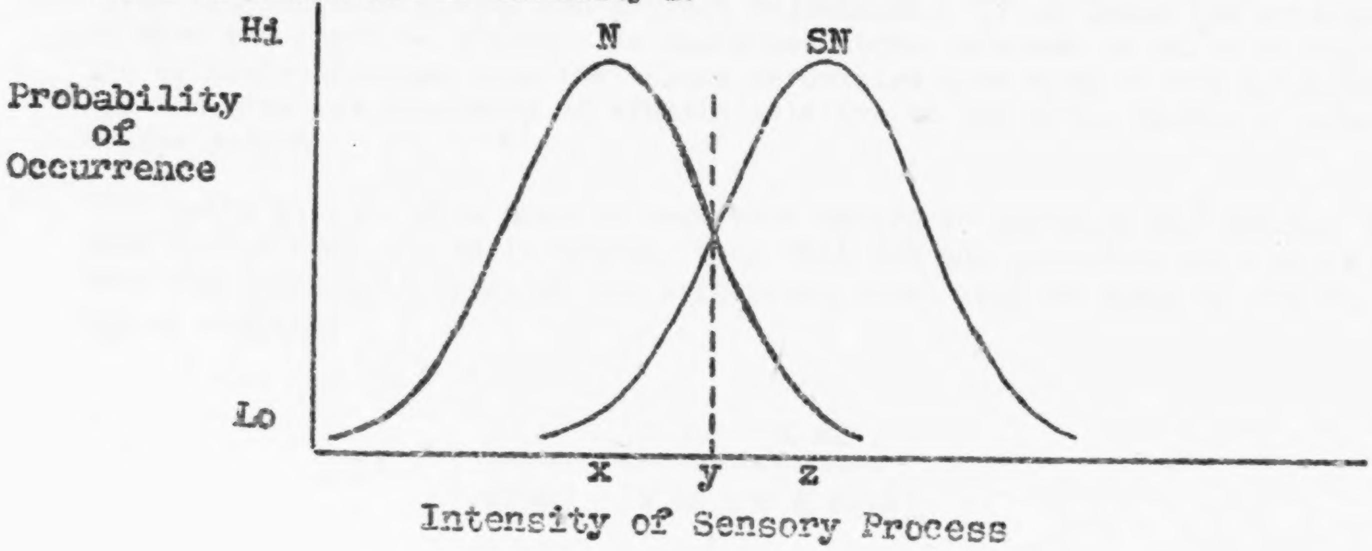


Fig. 1

Put in a somewhat more complicated fashion, the observer's decision about an event of intensity x depends upon the ratio of the probability of x occurring from signal plus noise, to the probability of x occurring from noise alone. This is called a likelihood ratio (because it is a ratio of one likelihood or probability to another). In the example described above the likelihood ratio at intensity y equals one; it is less than one at x and more than one at z. Our observer would say "yes, a signal was presented," whenever the likelihood ratio exceeded one. We might say that his criterion for saying yes was that a sensory event be more intense than y.

The value of the sensory event at which the likelihood ratio is one is not always chosen as the criterion. The choice depends upon two sets of factors, the relative frequency of the signal, i.e., on what proportion of the events requiring a decision is the signal actually presented and upon the positive and negative values associated with hits, misses, false alarms and correct rejection responses, i.e., the payoff matrix. For example, if the observer "knew" that the signal was present 90% of the times he was asked to make a decision, he would be wise to lower his criterion. Similarly if he gained a great deal by hits and lost relatively little by false positive responses, he would also be wise to lower his criterion.

It is of crucial importance to recognize the consequences of raising or lowering the criterion. Holding the means and standard deviations of the N and SN distributions constant, varying the criterion completely determines the probability of each of the four possible outcomes in the detection situation, namely, hits, misses, false positives and correct rejections. This is most easily seen by looking back at Fig. 1 and relating the probability of each outcome to the appropriate areas. Recall that whenever the intensity of the sensory event exceeds the criterion, in this case y, the observer will say "yes". The probability of a sensory event, resulting from noise alone, exceeding y is represented by the proportion of the area under the N curve lying above y; this determines the proportion of false positives. The probability of a sensory event, resulting from signal plus noise, exceeding y is represented by the proportion of the area under the SN curve lying above y; this determines the proportion of hits. In a similar manner the proportion of the N and SN curves lying below y are related to correct rejections and misses, respectively.

If we raise the criterion we necessarily decrease hits and false positives and increase misses and correct rejections. If we lower the criterion, we have the opposite effect. As mentioned above, whether we raise or lower the criterion depends upon the values associated with each of the outcomes and the expected frequency of signals relative to the total number of sensory events judged.

Swets *et al.*, show that if observers desire to maximize the average value they obtain over all their trials, they will set the criterion at a value such that the likelihood ratio at the criterion (Beta) will be equal to the following expression:

$$\frac{p\,(n)}{p\,(sn)} \cdot \frac{(V\ n.b + K\ n.a)}{(V\ sn.a + K\ sn.b)}$$

where p (n) = the proportion of trials on which no signal is presented,
p (sn) = the proportion of trials on which a signal is presented,
V n.b = the positive value resulting from a correct rejection,
**V sn.a = the positive value of a hit.**
**K n.a = the cost of a false positive**
**K sn.b = the cost of a miss.**

This is the standard equation for maximizing the average value of any series of decisions between two alternatives. It is quite familiar to economists who deal with decisions about investment on other economic matters.

Note that in order for the theory to be fully applicable to the detection situation, the observer has to "know" quite a bit. To the extent that this condition is not met, his performance will depart from the prediction made by the theory. The reason for the quotations around the words know and knowledge is that the observer need not be able to state the knowledge, he merely has to have had experience in the situation from which the knowledge could be induced. Indeed, it is not clear that just giving a verbal statement to the observer about the probabilities, values and costs will necessarily provide him with the knowledge needed for application of the theory. Typically, very well practiced and informed observers are used to insure meeting the requirements of the theory.

While this may seem like an irksome restriction, it is not really different than the previous practice of using experienced observers, nor is it different from physical laws which require an ideal situation, e.g., a perfect vacuum, for their perfect operation.

Although most readers will be confused and perhaps impressed by the time they have reached this point in their reading, some may also have begun to wonder what happened to the original problem threshold theories were designed to answer, namely the measurement of the sensitivity of observers to stimuli. In a sense, all that has gone before this has been an attempt to separate non-sensitivity, decision determinants of responses in a detection situation from sensitivity itself. Now we can turn to sensitivity. Let us look first at what the term sensitivity implies. The more sensitive a person is, the more he is able to react differently to signal plus noise and to noise alone. Increasing the sensitivity of an observer has the same effect on his performance as increasing the strength of the signal he is supposed to detect. In either case there is a greater likelihood of different reactions to signal plus noise and to noise alone.

In terms of the Swets model, increasing the strength of a signal has the effect of increasing the difference between the means of the distribution of sensory events due to signal plus noise and those due to noise alone. Remember that a signal was conceived of as adding a fixed amount of energy to a noise generated sensory event. If increasing the strength of a signal and increasing the sensitivity of an observer have equivalent effects, we can use the difference between the means of the N and SN distributions as our measure of sensitivity. This difference is called d′. Holding the intensity of the signal constant, d′ represents an observer's sensitivity. Holding sensitivity constant d′ represents signalstrength. The important point to notice about d′ is that it is completely independent of the decision processes of the observer. Regardless of where his criterion is, d′ is the same for a given observer at a given time with a constant intensity signal.

How do we measure d′ and how do we discover the observer's criterion? With yes-no responses d′ is estimated from the proportion of hits and false positives. Recall that the proportion of hits corresponds to the area under the SN distribution above the criterion value of the sensory process, while the proportion of false positives corresponds to the area of the N distribution above the criterion. Recall also that these are normal distributions. Therefore, we can tell how far the criterion value of the sensory process is from the mean of each of the distributions. We do this by looking in a table which lists the proportion of the area of a normal curve lying more than a certain number of standard deviations from the mean. For example if the proportion of hits is .80 and the proportion of false positives is .30 we would do the following.

a) First we see that the criterion is below the mean of the SN distribution because the probability of hits is greater than .50; only 20% of the area of the SN distribution lies farther below the mean. Looking in the table we find that this point is about 0.84 standard deviations below the mean. That is, under the normal curve, about 30% of the area lies between the mean and a point - 0.84 standard deviations from the mean.

b) We know that the criterion is above the mean of the N distribution because the probability of false alarms is less than .50. We also know that 30 % of the area under the SN curve lies above the criterion.

Therefore 20 % of the area lies between the mean and the criterion. Looking in our table, we discover that the criterion must be located approximately 0.52 standard deviations above the SN mean.

c) Since the criterion is 0.84 below the SN mean and 0.52 standard deviations above the N mean, the two means must be 1.36 standard deviations apart - this is our measure of d′. (See Fig. 2)

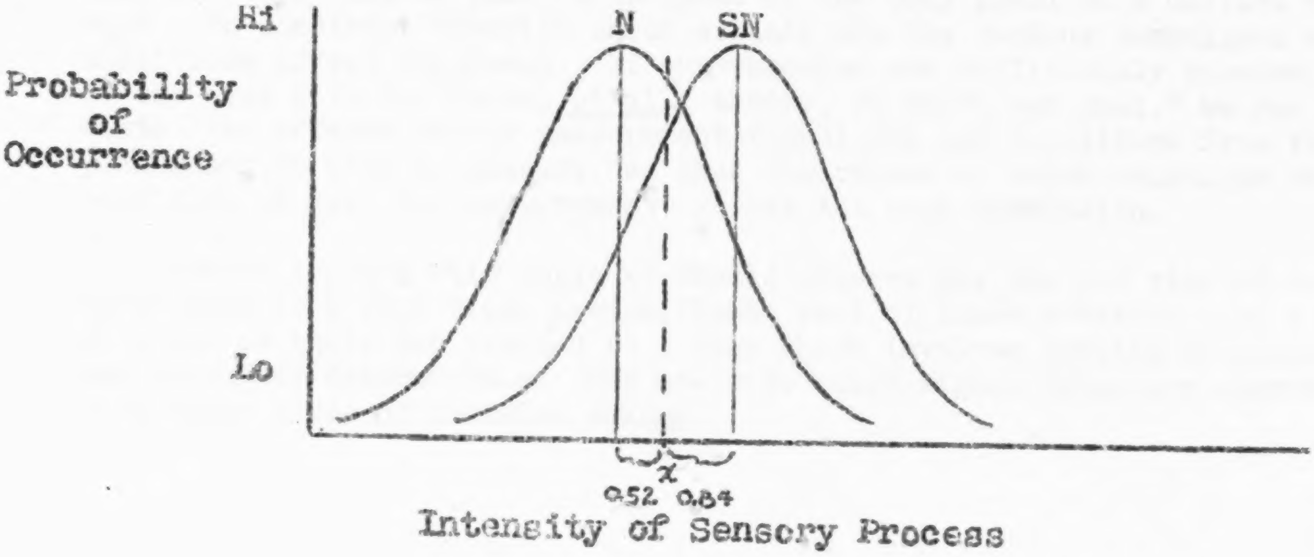


Fig. 2

When a forced-choice response system is used the procedure is more difficult. Swets, et al., have provided special tables for estimating d′ from the proportion of hits and of false positives.

Since the sensory process continuum is hypothetical, it doesn't make much sense to get a direct measure of the criterion value. Instead a measure of Beta, the value of the likelihood ratio at the criterion is obtained. This is done by generating an operating characteristic curve (see readings), holding signal strength and observer sensitivity constant and varying rewards or probabilities of signal occurrence. The value of Beta at any point on the curve is given by the slope of the curve at that point and requires determining the equation for the curve and obtaining the differential for the equation, and substituting the proportion of false positives for x and the proportion of hits for y.

General Comments

The Swets model, and some of the others as well, really treat the organism from the outside. What if anything a person actually experiences when exposed to a signal is of no concern to Swets and his colleagues. Their only concern is detection behavior. Their model allows prediction of detection responses under a variety of conditions and also permits the study of variables which are responsible for an observer's departing from ideal detection performance. As was mentioned earlier, the model does away with the threshold as a determinant of detection responses and substitutes two intervening variables, d′ and the criterion.

The evolution of detection theories is an interesting example of theoretical development. First we start with the naive assumption of a real threshold and the creation of techniques designed to measure it. Then we notice that different techniques yield different results and that extraneous variables such as rewards and expectations affect an observer's responses. At this point we stop being naive and begin to interpret our measures of thresholds with caution. We have eaten from the operationalist's tree of knowledge and know that the data yielded by our measurement techniques are not independent of the techniques themselves or of the conditions under which they are employed.

If we were to stop at this point we would be left with a fragmented set of theoretical concepts, one for each measurement technique and for each measurement condition. This is where simple minded operationalism would have us stop. But we push on in quest of the holy grail of a unified concept. We construct theories which explain how the various techniques and conditions affect responses. If our theories are sufficiently precise, as is the case with the Swets, et al., theory, we reach our goal. We can separate the effects of our measurement techniques and conditions from the phenomenon we wish to measure, so that regardless of which technique or condition we use, our measurement yields the same conclusion.

Before leaving this topic we should observe how the old view of detection, which made it a very tiny, insignificant part of human behavior, and a rather dull one at that, has yielded to a view which involves complex motivational and cognitive determinants. The new view makes signal detection continuous with other forms of decision making.

## Attention and Vigilance

When studying perception, it seems natural to ask how organisms discover their environments, how they find the information (thought of in the conventional sense) they need to construct adaptive responses. At first glance, information appears to be a scarce commodity, whose acquisition requires special effort and special explanation. Despite the intuitive appeal of this view, it is a dangerous one because it sidetracks inquiry from one of the major perceptual problems, namely, how organisms reject the abundant information proferred by their environments. Organisms are bombarded by complex distributions of photic, mechanical (especially sound waves) and chemical stimuli within the sensitivity ranges of their sense receptors. Were they equally responsive to all these energies, they would probably be unable to produce any consistent, adaptive reactions to their environments. Different aspects of the mass of stimulation would elicit different, at times incompatible responses and behavioral chaos would result. Stability and persistence of environment-response coordination require organisms to select the input to which they will respond and to reject the remaining inputs. Although this selective reduction of input is involved in many aspects of the perceptual process, it has received the greatest study in the area of attention. Indeed, the term attention refers to the way in which organisms select some parts of the stimulus energies, falling upon their receptors, for further processing in their perceptual systems.

The structuralists and other early psychologists recognized the importance of attention even though their research method minimized the role attention could play by drastically narrowing the complexity of the stimuli reaching their subjects.

The major interest was in the effects of attention on the experience of stimuli. Stimuli to which attention was paid were reported to be clearer and more prominent in experience. Titchner named this complex of properties attensity; it became one of his five dimensions of consciousness. As in the case of other aspects of perception, the structuralists appeared to be less interested in the process of attention than in its conscious results. Titchner described the attributes of sensations at the center and at the periphery of attention. Work was also done on the characteristics of stimuli that determined the level of attensity of the experiences these stimuli elicited. The major characteristics believed to increase attensity were: intensity, repetition, movement and change, novelty, and congruence with current mental contents. Titchner did recognize that habit could influence attention, but its operation was attributed mainly to brain physiology.

Despite its archaic character, Titchner's chapter on attention in his 1911 textbook contains faint beginnings of the modern view. He has a section on the span of attention in which he cites several respectable sounding experiments to support the view that the span of attention encompasses six units. (The number has suffered only slight inflation in the intervening years. Cf. G. A. Miller) Titchner also discusses the problem of the fluctuation of attention with the conclusion that it is due to adjustments of receptor organs (Cf. Broadbent, Holland and other vigilance investigators.) His most interesting discussion occurs in connection with what he called the accomodation of attention. In this situation the observer is asked to pay attention to a pendulum which swings in front of a protractor back round. The instrument is wired so that a bell sounds when the pendulum passes a specific point on the protractor scale. The subject is either asked to attend to the pendulum and report its position when the bell sounds or to attend to the bell and make the same report. Under the former instructions the pendulum is reported to be about 15 to 20 degrees further along its arc of movement than is the case when the bell is the object of attention. Which ever is the object of attention is experienced first. This has sometimes been referred to as the prior entry phenomenon. Titchner did not attempt to explain the result. However you should keep it in mind while reading the material in this unit, particularly Broadbent's writings.

For many years attention was a neglected area in psychology. Its revival is due primarily to the demands made by modern technology on human information processing capacities. This demand, coupled with the introduction of computer and communication system models into psychology, has created a growth of interest and knowledge in the area. Our concern will be with understanding the various theories of attention that have been proposed. These will be described briefly here and more fully in your readings.

The theories we will cover are not intended as complete explanations of all attentional phenomena. Most of them are fairly recent and have been developed with regard to a small range of phenomena. In some cases the phenomena do not overlap so that it is quite possible that full coverage will require a theory combining the features of several of the views treated here. You should attempt to note the congruences among the approaches.

The first theory you will meet is the filter theory, which holds that the attention process filters out much of the input to nervous system. Proponents of this view study the variables which determine the switching of the filter from one to another input channel.

The second view emphasizes the role of general arousal in attention. Much weight is given here to the operation of the reticular activating system. This view is not put forth as a complete explanation of attention because it could not account for some of the selective consequences of the attention process. The third position stresses the role of expectancies in determining the direction of attention. It is asserted that attention is directed to those areas and at those times at which important inputs are expected.

The fourth view makes attention a function of observing responses. These are never described in any detail, but they are said to be operants and therefor controllable by reinforcement schedules.

Finally there is a view which also treats attention as the consequence of observing responses, but here the responses are hypothetical central nervous system events. The occurrence of these events is said to depend upon a statistical decision process quite similar to the one we encountered in signal detection.

The actual situations in which attention has been studied are rather dull ones. Indeed, the dullness of the tasks has been an important factor in the development of the area. However, you should recognize that the processes described have considerable implications for the way in which we think about perception or behavior in general.

## Reading Notes and Questions

Allport, F. H., Theories of perception and the concept of structure. Chap. 4 pp. 67-95 (until Analysis of Core-context theory...)

Allport's purpose in this chapter is the same as the purpose of the lecture notes on Structuralism, viz., to describe the major aspects of the structuralist approach to the study of perception. As in the other parts of his book, he is very interested in raising questions which the approach did not recognize or at least di not answer. The book is very well organized but some of his discussions are unclear. The section headings should be used in ordering the material he presents and the questions he raises.

Some of the questions he raises are unanswerable, either because of technical deficiencies in our methods, conceptual deficiencies of our theories, or because of intrinsic limitations in the kinds of questions science can answer. The latter obstacle is one which concerns Allport throughout the book. He discusses his views on what science can and cannot study in the second chapter of the book. This is an extremely difficult chapter and although it presents the problem in a powerful way, the lesson it draws for the proper behavior of psychologists, namely that we all become physiological psychologists, is not convincing to many psychologists.

Listed below are some but not all the questions you should be able to answer about the reading.

1. How does Allport define the doctrine of the specific energy of nerves?

2. What faults does he find with the doctrine?

3. What alternative views concerning the relation between mind and body have been or might be considered besides that of psychophysical parallelism? (This requires you to go beyond what Allport states explicitly.)

4. What process besides association did the structuralists rely upon to explain the formation of experiential compounds?

5. What were the classes of sensory elements and attributes put forth by the several structuralist investigators?

6. Which type of element was basic? What was its relation to the other types? How is this view related to the epistemology of the British empiricists?

7. What was an attribute? What attributes did structuralists describe?

8. What difficulty developed with the conception of the relation between elements and attributes? How was the difficulty resolved?

9. Did Titchner think that introspection would allow us to observe the process of association? Why?

10. What problem was John Stuart Mill trying to solve when he introduced the notion of "mental chemistry?" What is Allport's view of the proper answer to this problem? (Allport lapses from his usual clarity in this section; you will have to do some extrapolating to get a reasonable statement of his solution.)

11. What distinction did the structuralists see between sensation and perception? (This is not stated directly, but is implied in the discussion of Titchner's theory of meaning.)

12. What is the essential theme of Titchner's core-context theory of meaning?

13. What is the relation between meaning and awareness according to Titchner?

14. What relation do you see between the concept of imageless thought which Titchner rejected and his view referred to in the previous question?

15. Referring again to question 12, why did Freud reject Titchner's view and consequent prescription for what psychologists should study? (This is not given in book, but knowing what Freud studied, you should be able to answer it.)

16. . What is meant by functionalism?

17. What is the meaning of the concept of unconscious inference? What problems does Allport see with the concept? (This is not the last we will hear of unconscious inference. Reserve judgment on Allport's criticisms until later in the semester.)

18. In what way did the discovery of the phenomena of the effects of sex on perception make trouble for the structuralists? (Here too we will have more to say later.)

19. With respect to which aspect of perception has the nativism-empiricism controversy been most frequently raised?

20. What was the theory of local signs? How was it related to the nativist-empiricist controversy?

21. What is the difference between "denotative" and "phenomenological" experiences as described by Allport? (This refers to another cloudy position which is treated at much greater length in Chapter 2.)

22. What two points of view are there concerning the importance of the distinction referred to in question 20? Which of these points of view would behaviorists find most congenial?

23. What was a form quality? How was it related to other sensory elements? Why did vonEhrenfels insist that it was a basic sensory element?

This last section takes us into the philosophical basis of Gestalt Psychology. It ought to be referred to again when reading Köhler's criticism of structuralist or analytic introspection.

24. Make a list of new terms and concepts you encountered in this chapter. Be sure that you can define each one and indicate how it is used.

Köhler, W. Gestalt Psychology, Chap. 2, section on isormorphism, pp.

Köhler was the member of the Gestalt triumvirate who was most concerned with elaborating the physiological aspects of the perceptual process. In his later years he took to experimentation in electrophysiological studies of brain functions. Despite their revolutionary status when introduced and the general disregard shown to them by neurophysiological investigations, the Gestalt ideas concerning brain functioning bear careful study. Ideas about brain functioning have loosened considerably since the introduction of the Gestalt model and some aspects of the model, e.g., gradients of neural activation, now seem more acceptable than they once were.

Whatever their ultimate status in the science of physiology, the Gestalt ideas concerning brain functioning do help in the understanding of the Gestalt approach. They tie together disparate phenomena with surprisingly few postulates. At the very least, they provide a convenient physical analogy or model for the otherwise distressingly abstract field forces in the Gestalt system. The fullest treatment of the model is given in a monograph by Köhler and Wallach, "Figural after-effects, an investigation of visual processes." Proceedings of the American Philosophical Society, 1944, Vol. 88, 269-357. The model also serves as an excellent example of the way physiology can be incorporated into psychological theories, and of the advantages and disadvantages such incorporation brings. This last aspect should be considered carefully during this unit.

1. Köhler appears to think that there is a difference between direct experience and overt behavior with respect to their contributions toward understanding nervous system functioning. What is this difference? Do you think it is justified?

2. What relation between physics and experience does Köhler cite as support for the view referred to in (1).

3. Which aspects of experience are assumed by the Gestatists to provide direct information about brain functioning? Which aspects of brain functioning are illuminated thereby?

4. Although isomorphism is not limited to experiences involving space and time, it probably is true that all aspects of experience that have the kind of direct relationship involved in isomorphism can be thought of in terms of abstract spatial dimensions. Indeed the very concept of variable is often represented as a spatial one, see for example the frequent graphic representation of relationships involving psychological variables. The generality of the abstract spatial aspect of psychological concepts broadens the potential application of the isomorphic principle.

5. How does Köhler justify the use of words in the study of the isomorphic relation between brain and experience? Why is he called upon to make such a justification?

## READING NOTES AND QUESTIONS

Hochberg, Triebel and Seaman, Color adaptation under conditions of homogeneous visual stimulation (Ganzfeld) in *R&W*, pp. 61-69.

This is a neat paper in which all relevant theories are confounded. The confounding of gestalt theory is due to the experiment going beyond the simple demonstration of the fading of color in a homogeneous field. (See lecture notes on introduction to gestalt psychology.)

Four simple experiments are reported. You should be able to state the purpose of each and the implications that the findings have for each of the several proposed explanations.

One finding in experiment C which puzzles the authors may have a simple explanation. This is the appearance of the illuminant colored halo around the shadow. The explanation depends upon the fact that the eyes are never at rest; even while we fixate they make rapid small movements. With this hint, try to explain the finding and suggest an experiment to test your explanation.

A very curious result, not explained by the authors is the fact that while a complete interruption of light for two seconds generally produced a burst of complementary color, a shadow cast upon the retina was generally seen as black. We shall return to this puzzling phenomenon later in this section.

* * * *

Katz, D. The modes of appearance of color in *R&W* pp. 83-89.

The major purpose of assigning this article is to provide an example of introspection, gestalt style. Despite its qualitative character, Katz's description can be readily checked and verified.

* * * *

Gelb, A. and Goldstein, K. Analysis of a case of figural blindness in Ellis' *Sourcebook...*, pp. 315-325.

Because of their stress on the importance of the brain in organizing perception, the gestaltists were quite interested in the effects of brain damage.

The case reported here is useful for gestalt psychology not because it provides proof for any of its propositions, but because it illustrates dramatically how essential the perception of form is to perception in general. It also shows the difference between the mere addition of parts and the organization of parts into a meaningful whole. Think of how the structuralists would have interpreted the case. Remember the importance of movement in the patients perception of form because later we will discuss a theory which holds that everyone learns to perceive forms the way the patient did.

## READING NOTES AND QUESTIONS

Köhler, Gestalt Psychology Today, *Reprint* 8 pp.

The Köhler writing this paper is much older than the one who wrote the previous material. His basic orientations, however, remain unchanged. He still prefers dynamic, field theories to mechanical, associationist theories. The historical perspective he gives at the beginning of the article is a good one. The paper was delivered as his presidential address to the American Psychological Association. Despite his election to that position, the position he expounds is still rejected by a very large part of experimental psychology.

Although perception is not the major content area discussed, the application of gestalt theory to motivation preserves and perhaps intensifies the flavor of the approach. Those of you who have taken the social psychology course will recognize the form of the theory mentioned by Köhler. The gestalt theory of motivation was primarily the work of Kurt Lewin.

The behaviorism criticized in this paper is much more complicated than the Watsonian variety he treated in the first chapter of *Gestalt Psychology*. Much of the change has come about because of criticism inspired by gestalt psychology. As a result of these changes, many phenomena previously explainable only within the gestalt approach can now be explained as well if not better by one or another of the behaviorist theories. The increase in complexity of behaviorism and the increase in rigor of gestalt psychology has brought the two closer together. (See D.T. Campbell "Social attitutes and other acquired behavioral dispositions" in Vol. 6 of Koch's *Psychology: The study of a science* for an excellent treatment of this rapproachment between the two approaches.) Nevertheless, despite the ability to translate from one approach to the other in many areas, the style of attack and the questions attacked by gestaltists and behaviorists remain quite different.

1. What is Köhler's orientation toward caution and the critical spirit in science? Do you think he is right? Why?

2. How does gestalt psychology extend the principle of relational determination of psychological phenomena to the field of motivation?

# READING NOTES AND QUESTIONS

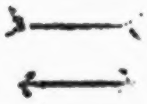
Köhler, W. *Gestalt Psychology*, Chaps. 3 & 4.

We begin Köhler's classic with chapter 3 in order to preserve continuity with our previous topic. The first two chapters of his book are devoted primarily to a criticism of behaviorism and the pre-mature stress on precision in psychology. These chapters will be treated later. For the present you can rely upon your general knowledge of S-R behavior theory, as presented in the learning section of the elementary course and in other courses on learning.

Two definitions might help you in reading the material in chapter 3. The first is of Köhler's concept of "objective experience." This refers to experience which we localize in the physical world of our environment or our bodies. It is used in contrast to "subjective experience," which we localize in our minds, e.g., our emotions, ideas, dreams, etc. The distinction deals with the contents of experiences. Generally speaking, the psychology of perception is concerned with the study of objective experience.

The second definition is of the Müller - Lyer illusion. This familiar stimulus is shown below. The two horizontal lines are of equal length.

A word of warning: The chapters in *Gestalt Psychology* have no internal subdivisions. It is therefore necessary to impose an outline upon them after they have been read.



## Chapter 3

1. Compare Köhler's description of structuralism (intro-spectionism) with what you know of it. Do you think it is a fair representation? Why?

2. What is the introspectionist distinction between sensation and perception, according to Kohler? Indicate how each of the examples he presents in the early part of the chapter is related to this distinction.

3. What is the relation between the sensation-perception distinction and the "empiristic" hypothesis?

4. Having made the distinction referred to in the previous questions, which of the pair did the structuralists prefer to study? How is this preference related to the quotation at the start of the chapter and to Köhler's view of what ought to be studied?

5. What reason does Köhler give for the introspectionist adherence to their view of sensation? How does it compare with the ideas presented in the lecture notes on structualism?

6. What does it mean to state that "true sensory facts" are local phenomena?

7. What relation does Köhler see between the structuralist view of sensation and the behaviorist view of stimulation?

8. At this point in your reading, what change do you think the gestalists want to make in the structuralist notion of sensation and in their view of the relation between sensory experience and the nervous system? (Note: Köhler has said enough by this point to allow an educated guess on your part. You should make an attempt to answer this question because it should reveal to you whether you have understood the criticisms he has made of structuralism.)

## Chapter 4

In this chapter Köhler discusses two types of molar (involving large aggregates of molecules, rather than single molecules or atoms) energy systems: machine and dynamic or field systems. These should be taken as general descriptions of ideal types not as precise definitions. At the molecular and atomic levels the distinctions he makes probably disappear because even machine systems ultimately depend upon field processes, but to keep this in mind at the outset is to blur a useful distinction. It is important for you to get an intuitive grasp of the distinction he describes because it helps to convey the major difference between Gestalt theory, on the one hand, and structuralism and behaviorism on the other. Later we will look at a theory of perception which attempts a rapproachment between gestalt and associationist theories, but for now you must attempt to make the distinction as sharp as you can.

Some definitional, etc., notes: (a) The terms field theory and dynamic theory are used interchangeably in psychology, with the former appearing more frequently in discussions of gestalt theory. (b) Despite Köhler's efforts at coining a new word, namely "empirist," the older term empiricist is currently used to refer to psychologists as well as to philosophers. (c) The facts with respect to constancies in animals and children are not clear; they do not rule out the empiricist position as easily as Köhler implies.

1. In what way are the structuralist and behaviorist conceptions of the sensory aspects of the nervous system machine alike? (See question 7 above.)

2. What is meant by reacting to a sensory scene rather than to a mosaic of local sensations? (cf. question 6 above.)

3. Compare field and machine systems with respect to the way in which energy gets directed and distributed in an orderly fashion.

4. Why does the term "self" appear in the phrase "dynamic self distribution of forces in dynamic field systems?" (cf. preceding question)

In discussing the difference between the structuralist and gestalt views of the role of the nervous system in perception, the former has often been called peripheralist while the latter has been called centralist? Why are these labels fitting?

5. What is the end toward which all dynamic systems tend, barring outside constraints and forces?

6. Why did Kohler find the structuralist view of contrast more acceptable than their view of perceptual constancy?

7. How does Köhler reconcile his view of visual experience as dependent upon field processes and the anatomical fact of point for point correspondence between retinal cells and corresponding cells in the visual projection area of the cortex?

## Reading Notes and Questions

III B 2 Köhler, W. Gestalt Psychology, Chap. 5.

1. What does Köhler mean by the organization of the field? (Here he refers to the experienced field.)

2. What are the several empiricist explanations of this organization? With what arguments does Köhler refute these explanations? (It might be a good idea to list all the arguments and counter-arguments in the beginning dialogue.)

   Note: One of Köhler's arguments states that the similar members of a sensory group move independently hence seeing them together occurs in spite of previous experience with them rather than because of it. This is a questionable assumption. Even Köhler himself indicates later in the chapter that perceived entities are likely to correspond to physical entities. If this is true then the several parts of the perceived entity are not likely to move independently.

3. If, as is suggested in the above note, Köhler is wrong about the independence in the movement of the parts of a perceived entity, which empiricist argument benefits?

4. Why is the term spontaneous applied in describing the grouping that is characteristic of the experienced field?

5. Köhler refers to two types of grouping principles; what is the difference between them?

6. What was the purpose of Hertz' bird experiments. What were the variables in the experiment?

7. What is the significance for Gestalt psychology of the reactions of persons who have gained sight for the first time and are asked to name simple visual figures?

8. What relations do Gestalt psychologists see between space and time with respect to their effects on sensory organization?

9. What relation has been proposed by structuralists and others between sensory organization and eye movements? Why does Köhler think this proposal is wrong? What relation does he think usually exists? How is the Gelb and Goldstein case relevant?

10. What is the stimulus error? What is the experience error? Which does Köhler think that critics of gestalt psychology, particularly behaviorists, often make?

11. How would the gestaltist alter the S-R framework of the behaviorist - what would he add? Why?

12. Which aspects of a stimulus array are critical in determining the organization imposed upon the input?

13. What is the gestalt distinction between genuine and "non-genuine" parts of wholes?

* * * *

III B 3 Wertheimer, M., Principles of perceptual organization in B&W, pp. 115-136.

Most of this classic exposition is quite straightforward, but it may be hard reading because it has been condensed. It is important to try out each of the demonstrations yourself as you read. Straight reading will leave you very unorganized. As you try out the demonstrations note the instability of some of the configurations. The very same stimuli produce different organizations. Do a bit of gestalt-like introspection and try to describe what this difference is. See also if you can get the changes under voluntary control and if you can, how did you do it?

After reading the selection, list the principles described. Be sure that you know which demonstrations go with which principles.

Pay careful attention to the criticisms made of the empiricist position. People generally exaggerate the degree to which the gestaltists rejected past experience as a determinant of perceptual organization and overlook the reasons for the rejection that did occur.

* * * *

III B 5 Koffka, K. Points and lines as stimuli in B&W, pp. 70-82.

This is an excerpt from a beginning section of Koffka's Gestalt Psychology.

Koffka begins his treatment of perception with a consideration of the simplest possible stimulating condition, namely a completely homogeneous field. The selection by Rubin (III B 4) is the source of some of the material discussed by Koffka in this case. He then proceeds to the case of a single homogeneous blob in the center of an otherwise uniform field. The assigned selection is the third situation he covers. As is often the case in early gestalt writings, part of the exposition is devoted to a refutation of the empricist explanation of the phenomena considered.

1. Which mode of operation of the Prägnanz principle applies to the difficulty of seeing a point in an otherwise homogeneous field.

2. Why does Koffka stress that the perception of a single point in a uniform field is such an unusual case?

3. What does Koffka mean when he writes of the assymetrical segregation produced by the contour which encloses an area? To which of Rubin's points is Koffka's point related?

4. What is the purpose of Koffka's discussion of the difference between a circular and triangular contour?

5. Which of Wertheimer's laws of sensory organization (III B 3) seems most important in determining whether a closed contour with internal lines is seen as one or more figures?

6. What was the purpose of the Gottschaldt experiment?

7. Gottschaldt used a simple, passive kind of experience in his study probably because this was easily done and because the empiricist theorists never specified just what kinds of experiences were important in learning to perceive figures. What other kinds of experiences might he have used? Which of these might have produced different results? (Return to this question after reading the Hebb selection - IV)

III B 6&7 Fuchs, W. On Transparency and The Influence of form on assimilation, in Ellis, pp. 89-103.

All of the demonstrations discussed in these two selections might be said to illustrate the principle that the characteristics of a part depend upon the whole in which it is located. All of the demonstrations show how identical stimuli produce different effects when the organization of fields varies. It is important to keep this general principle in mind as you go through the details of the demonstrations. The details may be a bit confusing. Don't read them in a cursory fashion. Try to understand what was done, what was found and why it was found for each demonstration as it is presented. We will attempt to repeat some of the demonstrations in the lab.

1. What is meant by transparency?

2. Why is the demonstration of transparency of such great importance to gestalt position? (In answering this question it is useful to think of why the structuralists would have trouble in explaining transparency.)

3. What orientation must be maintained by the observer in order for transparency to occur. Does this limitation in the conditions under which transparency takes place cause embarrassment to the gestaltists? Why?

4. What are some of the stimulus arrangements that help the subject to maintain the orientation referred to in the previous question?

5. Think of the puzzling finding in the Hochberg, Triebel and Seaman experiment in which a shadow cast upon part of the washed out ganzfeld was generally seen as black, surrounded by a halo the same color of the illuminant, while a complete block in the illumination produced a flash of complementary color. Now think of the Fuchs demonstration illustrated in Figs. 6 & 7 of his article. Having considered these two apparently different phenomena, perform an act of insight which relates the two. (Hint: think of the difference it would make if the subject, looking at the partially shadowed ganzfeld, were to see the shadow in front of or behind the foggy ganzfeld area.) Finally, think of an experiment which tests the validity of your insight.

6. The Fuchs demonstrations involving the episcotister and the colored E illustrate both modes of the operation of the Law of Prägnanz. Be sure you can specify which phenomena illustrate each mode.

III B 8 Fuchs, W. Completion phenomena in hemianopic vision, in Ellis, pp. 344 - 356.

It is useful to know what hemianopia and amblyopia are before reading the article. The former refers to a defect in which no stimulation is received from one part of the visual field. It is likely that the cases discussed by Fuchs are ones in which damage to the head destroyed one or the other of the optic tracts between the optic chiasma (where the crossing over occurs) and the brain cortex. Such damage would result in loss of vision from the right or left half of the visual field. Unfortunately no information about the injuries is given by Ellis so that it is not possible to be sure that the defects were not due to cortical damage. If cortical damage were present, the gestaltists would have a good deal of trouble explaining the results. Why? Amblyopia refers to reduced or partial vision in a portion of the visual field.

This paper by Fuchs is another in the series of studies of men suffering neurological damage as a result of war injuries. A major purpose of most of these studies was to illustrate that perceived figures functioned as unified wholes rather than as collections of points. Although this position has sometimes been summarized by stating that the whole figure is greater than the sum of its parts, it might be more accurate to state that a figure has dynamic properties (i.e., sets up field forces) which are *not at all* present in the parts taken one at a time.

The dynamic significance of wholes as opposed to single parts seems so simple that one might wonder why so much data was collected to illustrate it. There were two reasons. The first was polemical; the research was done during the period of structuralism's ascendancy in psychology. The structuralists were rather stubborn in holding to their view that sensations were essentially mosaics of non-interacting parts. The second and more important reason was that of gaining a greater understanding of the conditions under which the dynamic effect of wholes, e.g. completion tendencies occurred. From a pedagogical point of view the profusion of demonstrations is valuable because a *general* principle can't be taught without many illustrations.

There are a number of conditions discussed by Fuchs. You should list these after you finish reading the paper along with the demonstrations which illustrate their effects.

In connection with his discussion of the effects of variation in the form of figures upon the completion tendencies they generate, Fuchs mentions the idea of requiredness. Some figures seem to require or demand specific additions to make them complete in a specific way. This feeling of requiredness is also experienced strongly in the perception of auditory figures, e.g. rhythms or melodies. The phenomenon of syncopation depends upon the actual or rhythms departing from the ones demanded by the preceding incomplete auditory figure. The demanding quality created by some incomplete figures is as close as we come to experiencing the forces at work in the hypothetical perceptual or brain fields.

Two other noteworthy themes appear in Fuchs' article. The first is the stress on central (i.e., cortical) determinants of perception as opposed to peripheral (i.e., receptor) determinants. The reason for this stress is to point up the inadequacy of the structuralist position. The structuralists believed that sensations corresponded to brain processes, which were in perfect, point for point correspondence with the receptor processes to which they were linked. Therefore their physiological explanations of sensations relied heavily on receptor processes. The gestaltists, on the other hand, believed that the brain cortex was the locus of the field phenomena which were the physiological counterparts of sensory experiences. Since field processes did not occur in the receptor organs, the gestaltists concentrated their physiological explanations on the cortex.

The final important theme concerns methodology. We must always infer a subject's experienced field from his verbal or other overt responses. Usually more than one inference can be made from a single response. Therefore additional responses must be observed in order to rule out alternative explanations. The gestaltists were often insensitive to this problem. Fuchs did recognize the difficulty and in the latter part of his paper he describes how he went about increasing the certainty of the inferences he made.

As in the other papers by Fuchs, there are a large number of demonstrations. Each should be read carefully and thought about before going on to the next.

III. C. Wallach, H. Brightness constancy and the nature of achromatic colors. B&W, pp. 225-242.

Hans Wallach was a student and close collaborator of Köhler. He came to the USA from Germany with Köhler in the thirties. Since that time he has been at Swarthmore College and is currently chairman of their Psychology department. He is among the most rigorous of psychologists, gestalt or otherwise. His strong point is insightful, thorough and careful investigation of specific phenomena rather than the elaboration of gestalt theory.

A few definitions will be helpful before reading the article.

a) Achromatic color refers to the grayness color dimension, which varies from black to white. It is a property of objects the way any other color is.

b) Illumination refers to the light falling upon an object.

c) Luminance refers to the light emitted by a source of light.

d) An episcotister is a rotating disc, with a segment cut out of it. When an episcotister is placed between a light source and an object, the amount of light falling upon the object is proportional to the size of the cut out segment.

In following the demonstrations involving discs and rings, you might find it helpful to draw simple diagrams of the stimuli to keep the relations among the several light intensities clear.

Throughout the paper remember that the phenomenon is still another example of the relational determination of perception.

1. What conditions were necessary for the emergence of surface color? If these were not met, what was the perceptual result?

2. What is brightness constancy?

3. To which physical property of a single object does our perception of the object's achromatic color correspond? Why is this a problem for the psychology of perception?

4. How do the phenomena discussed in part I of Wallach's paper compare with brightness constancy? Is brightness constancy a special phenomenon requiring its own explanation?

5. How does Wallach account for the fact that under normal conditions, brightness constancy is far from perfect?

Consider the phenomenon of brightness contrast in which the difference in achromatic color between adjacent areas is is exaggerated in perception, with amount of exaggeration being proportional to the actual magnitude of the differences in light reflected from the areas. Now consider two observations which Wallach cannot explain. The first is the fact that the disc in the dim ring has to be made brighter than would be expected on the basis of his theory in order to be seen as equal in brightness to the disc in the bright ring. The second is the fact that the same intensity of light reflected from a disc, holding all other factors constant.

Now perform an act of insight and explain Wallach's unexplained observations. Think of how you would test your explanation.

III. D. Until this point we have touched very lightly on the physiological theory held by the gestaltists. As was mentioned in previous notes, the early gestaltists considered their physiological theory the ultimate explanation of the phenomena they investigated. Köhler continues to believe this. Despite the fact that there are very few adherents to the gestalt view of brain functioning, it is presented because it is needed to get a full picture of the movement. In order to examine it at its best, it is discussed in connection with a phenomenon which it helped to discover and which it does a good job of explaining. The phenomenon is figural aftereffects. The original work on it was done by Köhler and Wallach.

III. D. 1. Köhler, W. Gestalt Psychology, Chap. 2, last part of chapter on isomorphism, pp.

This and the following reading make it clear that the gestaltist derive their view of the nervous system from the knowledge of perception rather than vice versa. Put somewhat differently, Köhler searched for possible physiological models until he found one that could account for the phenomena discovered by the gestaltists.

1. Why does Köhler believe that the study of perception can help in learning about the nervous system?

2. What is the principle of psychophysical isomorphism? What is its relation to the issue raised in the previous question?

3. What is the difference between isomorphism and the structuralist notion of psychophysical parallelism? How are the two notions similar?

III. D. 2. Köhler, W. Dynamics in Psychology, Chap. 2.

The beginning of this chapter provides arguments for the use of physiological explanations in psychology which would find acceptance among a large number of psychologists. Indeed, they are probably more accepted today as the result of the rapid growth of research in physiological psychology than they were in 1938 when the arguments were put forth. However, the position is still a controversial one.

There are many who would welcome psychophysiological research as useful additions to the unity of science and who would share with Köhler the goal of being able to cross the boundaries from sociology to physics without having to cut through barbed wire. They might even go as far as agreeing that until such transitions or translations from one level of analysis to another are made, much will remain unexplained. However, they would argue that there is much to be gained from continuing to work just at the psychological level, particularly at at present when knowledge of the neurophysiological processes corresponding to psychological processes is very scant. They would hold that most of the neurophysiological explanations proposed for psychological phenomena are just as hypothetical as the purely psychological ones. They would add that many people are deluded by the concrete sounding language of physiological explanations into thinking that the bed rock upon which secure psychological knowledge could be erected.

These arguments are particularly applicable to Köhler's theory. His physiological explanations are less substantial than the phenomena they are supposed to explain. On the other hand it should be recognized that the figural aftereffect work is at least in part a consequence of the physiological theory. Hence the theory has performed one of the primary functions of any theory; it has lead to the discovery of new phenomena. Köhler is currently engaged in physiological research in which he attempts to obtain electrical records of brain field activity. A paper in the American Psychologist, 1958, Vol. 13, pp. 150-154, summarizes some of his findings. We shall return to the discussion of the role of physiology in psychology later in the semester.

In reading the part of the chapter describing brain field processes, think back to the lecture notes on gestalt theory and connect the points made there with the features of the brain model presented by Köhler. Once again, pay close attention to the examples and to how the phenomena they illustrate would be explained by the gestalt physiological theory.

Werner, H. and Wapner, S. "Toward a general theory of perception" B & W, pp. 491-512.

We study Werner and Wapner's sensory-tonic theory of perception at this point because it is an offshoot of the Gestalt approach. As has been mentioned several times, Gestalt psychology was not limited to the study of perception, although the largest part of its efforts and contributions lay in that area. Heinz Werner received his degree from the University of Vienna in 1916 and despite the distance between the gay capital of the decaying Austro-Hungarian Empire and stark, Prussian Berlin (the home of the Gestalt movement), he was undoubtedly influenced by the revolutionary psychological currents emmanating from the north. Werner tried to study perceptual and cognitive development and personality organization using Gestalt concepts. His was one of a number of such attempts at a wholestic approach. His views might be seen as radical development of the revolutionary ideas put forth by the originators of the Gestalt movement.

The main stream of Gestalt psychology did not move in the direction advocated by Werner. His work was used primarily by students of personality and child development, despite its perceptual flavor. The Gestaltist mainstreamers did not like to deal with phenomena which could not be brought into the laboratory for experimental study. Despite the unempirical connotations that many Gestalt views have for Americans, grounded in Behaviorism, it should be remembered that the proponents of the theory conducted active experimental research programs. By the late 1940's the Gestaltists dominated the study of perception, they had become the "conservatives" and were subjected to a challenge from a new left, (called the "new look") the personality oriented wholests. We well treat this new movement later on, for the present it need merely be said that Werner's work found the new look milieu a nourishing one. As is pointed out in the introduction to the article, Werner and his younger colleague, Wapner, thought their theory could serve as the synthesis in the dialectic confrontation between the Gestalt establishment and the new look rebels.

The promissory note issued in the article you read was never delivered. Yet the work is valuable because it emphasizes the role of motor components in perception. This is not at all a new idea; Titchner placed great emphasis on kinesthetic images in the context which provided meaning for visual sensation. However, the Gestaltists paid little attention to motor aspects of perception. Werner and Wapner showed that one need not take an associationist point of view in order to incorporate motor aspects into visual perception. They may also have gone beyond the conventional view of kinesthetic feedback. Their theory was also more compatible with the complex cross-modal neurological interactions that almost certainly occur while we perceive and the close mixture of sensory input and motor output fibers in many areas of the brain. Perhaps the major problem with the theory is the vagueness of some of its major concepts and the difficulty of seeing how they could be generalized beyond the phenomena involved in the perception of body location and orientation.

1. What is meant by the projective nature of perception?
2. What is the paradox of interaction referred to by the authors? Do you think it is a paradox? Why?
3. What is the meaning of "tonic" in the term sensory-tonic.
4. What is the relation between the "tonic" aspects of perception and kinesthetic stimulation.
5. What is meant by functional equivalent in the sensory-tonic approach.
6. What kind of field is envisaged by Werner and Wapner?
7. What is the kind of equilibrium maintaining process in which the authors seem most interested.
8. What is the apparent vertical?
9. What is the relation between the apparent vertical and the equilibrial axis?
10. What variables have been shown to influence the apparent vertical?
11. What processes do the authors hold responsible for the effects described in the previous question? Try to list thepostulates and assumptions implicitly (or explicitly) contained in their discussion.

89

12. What effect is the viewing of a tilted line supposed to have on the equilibrial axis? How does this effect compare with the supposed effects of extraneous stimulation and body tilt? Does their theory account for this relationship?

13. What variables have been found to influence the perception of the median plane?

14. As in the case of the apparent vertical, not all variables produce the same effect on the perception of the median plane.

15. What do authors mean by "symmetrization?" What is the relation between this concept and Gibson's concept of "normalization?"

16. What differencesdo the authors suggest concerning the effects of figures and grounds on sensory-tonic fields?

17. What is meant by vicariousness? What observations have been used to illustrate the concept?

18. The author's use the standard "it can easily be shown" technique in referring to the relation between direction of walking while blindfolded and tilt of the apparent vertical with no extraneous stimulation. Can you show how they arrive at their prediction?

19. What differences have been observed in "symmetrization" of rectangles and triangular or "directional" objects?

Witkin, H. "The nature and importance of individual differences in perception," B & W, pp. 513-524

This was one of the early papers in the "new look" movement. The phenomena described in it were thought to have revolutionary implications for the study of perception. At the time many believed that the wall between the staid, black-room psychology of perceptual investigators and the faintly disreputable, murky psychology of the personality clinic had been breached for good. However, the wall proved more durable than had been expected by the personality oriented researchers. Once through the wall, their ignorance of the perceptual terrain made them easy prey for the hawk-eyed perceptionists. After a few years of lively battle, the personologists retreated and the wall was rebuilt.

Although the attachers felt they were carrying a new, superior insight to the ancient land of the black rooms, they had very little impact on the conduct of perceptual research. To the contrary, the personologists were influenced by the perceptionists. Although we cannot trace this influence here, it should be noted that much of the current experimental work in ego psychology and cognitive styles stems from the results of the new look war.

Another phenomenon, common to most ideological conflicts, is that there were defectors on both sides. Witkin was one of these. Trained as a Gestalt psychologist, he became a personologist who studies used perception as a means of studying the subject matter at the center of his interest. This reading is bracketed with the one by Werner and Wapner because the specific perceptual phenomena investigated in the two are similar.

1. What feature is common to the variety of test situations used by Witkin?
2. What does Witkin mean by repression in perception? Under what conditions does he think such repression takes place?
3. In which aspect of his results does Witkin appear most interested?
4. How would Witkin's results be handled by sensory-tonic theory?

Woodworth, R. and Schlossberg, H. *Experimental Psychology*, section entitled, "Pursuit movements and the perception of motion," pp. 510-517

1. What are the two kinds of eye movements we make when fixating moving objects?
2. We perceive movement when the eye is stationary and the retinal image ______. We also perceive movement when the eye is moving and the retinal image ____________.
3. What is the Phi phenomenon?
4. What are the two "thresholds" involved in the perception of successively flashed lights as the interval between them decreases?
5. What are Korte's Laws?
6. What other factors influence the perception   the successively flashed stimuli use in Phi demonstrations?
7. Note well the  ittle discussion on the immediacy of the effect.
8. Wertheimer first introduced the Gestalt brain field theory in connection with the Phi phenomenon; however, it was Köhler who developed the theory most fully.

Koffka, K. Perceived Motion. *B & W* pp. 368-374

1. What general condition is required for the occurrence of a perception of motion?
2. Even though the general proposition referred to in (1) cannot be tested directly, it does lead to another proposition concerning variation in the ease of perceiving motion. What is this proposition?
3. What proposition did Duncker introduce concerning the perception of motion when a figure and ground are displaced with respect to one another? What analogous propositions have already been introduced concerning the perception of changing the hue of the illumination falling on a stationary figure and ground?
4. Relative displacement determines the ____________, but not the ____________ of perceived motion.
5. What is meant by the invariance of perceived motion? Under what conditions does this invariance break down?
6. Gestalt theory provides the same explanation for real as for stroboscopic motion. The explanation is an extension or application of Wertheimer's laws of organization, with primary emphasis on contiquity. One of the elegant things about the explanation is that is suggests a host of stimulus variables which ought to affect the perception of apparant motion. Some of them have been tried and have been found to produce the expected results. Koffka describes a few of these in this selection. You will come across more in the other Koffka reading.

Wallach, H. The perception of motion

The major purpose of this little article is to describe some of the very compelling demonstrations of relational determination the perception of motion. As in the case of stroboscopic movement, the application of the Gestalt principles of sensory organization yields a large number of fascinating predictions. Even when the phenomena can't be predicted on the basis of Gestalt theory, they appear to be consistent with the gener idea of perception being determined by the relations among stimuli.

~~Wallach, H. "On the constancy of visual speed." B & W, pp. 375-381.~~

1. ~~What is meant by the constancy of visual speed?~~
2. ~~What is the explanation of visual speed constancy which depends upon size constancy?~~
3. ~~What is the transposition principle in the perception of velocity?~~
4. ~~Which of Brown's findings does Wallach view as paradoxical? (This may be a bit puzzling because the explanation Wallach finally offers, is fairly evident, thereby weakening the paradox considerably.)~~
5. ~~What does Wallach do to show that the situations involving a visual speed constancy and transposition are identical?~~
6. ~~What variable can be used to alter the degree to which transposition or constancy take place? What appears to be responsible for this alteration?~~
7. ~~What aspect of the phenomenological field is invariant in both situations?~~

Koffka, Gestalt Psychology, Chap 7, pp. 284-304.

Koffka's book was the last and most systematic of Gestalt treatises. It is less polemical than Kohler's Gestalt Psychology and considerably more detailed. The section on motion is a difficult one but well worth study (as is the entire perceptual part of the book). It is an example of Gestalt psychology at the height of its development. The experiments described here are real experiments, not just demonstrations. The theory leads to fairly clear predictions, not just intuitive hunches.

The reading starts near the beginning of Koffha's section on motion. The points he makes in the first few pages of the section have already been covered in the other things you have read about the perception of motion. There is some slight overlap in the material of the previous and present Koffka readings.

1. Why does Koffka find it necessary to introduce the Ego into the field motion and hence to vary the nature of the motion perceived. Such experiments might be feasible projects.
2. What do you think he means by the Ego?

3. What evidence does he produce that supports his views about the Ego being a part of the field?

4. His brief discussion suggests experiments in which conditions are manipulated to vary the role played by the Ego in the perception of motion and hence to vary the nature of the motion perceived. Such experiments might be feasible projects.

5. The term process distributions refer to the same things as Kohler's current flows in the brain.

6. What does Koffka mean by the terms, "dynamically identical?" and "fusion?" (cf. (cf. Note 6 for the Koffka selection in B&W)

7. What implication is drawn from the fact that two stroboscopically exposed lines appear at a shorter distance from each other than two permanently exposed ones?

8. The Brown experiment discussed here is the same one treated in Wallach's article on motion constancy.

9. What does Koffka mean by the principle of displacement in his discussion of Brown's results? What principle does he suggest which makes it reasonable that constant sized objects with equal true velocities should have lower phenomenal velocities in large rather than small fields. Remember the phenomenon discussed by Koffka here; it will be relevant to a topic we discuss at the end of the semester, viz., frames of reference in judgment.

10. What is meant by objective stroboscopic velocity?

11. What relation does Koffka show between Brown's results and Korte's Laws? It helps to have Korte's Laws before you as you pick your way through this difficult passage. They are given in the Woodworth & Schlossberg reading. In their description they refer to factors which make it likely that the two flashes will be seen as simultaneous rather than in motion. The change from perceived motion to perceived siumltaneity can be thought of as an increase in perceived velocity. This provides the essential link between Korte's and Brown's findings.

    In looking at the relationship between the two sets of laws, one must think first of the effects that variation in distance or time between flashes has on stroboscopic velocity. Then one must ask what effects if any the change in stroboscopic velocity will have on the perceived velocity of apparent movement in the stroboscopic situation.

    One interesting question regarding stroboscopic velocity has not been raised by Koffka, although he seems implicitly to assume an answer. Is the perceived velocity of optimal stroboscopic motion always the same? Koffka's discussion on pp. 293-4 appears to assume an affirmative answer. However, his discussion on p. 295, of his zone law implies that this optimal perceived velocity is a range, not a point, and that the range is inversely proportional to the magnitudes of times and distances involved.

    Koffka's theoretical equation of two previously separate phenomena brings joy to the heart of a theoretically inclined scientist. By this feat he simplifies his account of the universe and enables himself to predict new pehnomena. All the variables which have been found to affect phenomenon A can now be expected to affect B and *visa versa*. To be sure most of these new predictions must be checked empirically, but if the theoretical identity is correct, all checks will produce the hypothesized outcomes and after a while one will be able to transfer knowledge from one phenomenon to the other without having to resort to empirical tests.

12. In reading about Brown's work on phenomenal time, be sure to remember that the lower case letters refer to preceived or phenomenal variables, while the upper-case letters refer to objective variables.

13. Following what was said above, time phenomena discovered by Brown should apply to the stroboscopic situation as well.

14. What was the problem investigated by Ternus? What is its relevance to the Gestalt theory of motion?

15. What is meant by the term "gestalt-homology of parts?" How is it related to fusion?

16. What relation does Koffka propose between spatial patterns perceived in figures at rest and spatio-temporal patterns perceived in figures on motion?

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1. Why does Koffka find it necessary to introduce the Ego into the field

2. What do you think he means by the Ego?

## IV. A. Hebb, D. O., The Organization of Behavior

### Introduction

1. What is the problem in the explanation of behavior that Hebb believes neither field nor association theories have been able to solve?

2. In his discussion of parallelism, Hebb may misrepresent the views of psychologists who use mentalistic theoretical constructs to explain how a given stimulus eventually elicits a given response. To say that a person is more frequently able to identify a tachistoscopically flashed stimulus correctly when he expects it than when he does not is not to argue that a mental (nonphysical) event, the expectation, had an effect on a physical one, the overt identification response. No scientific psychologist believes that there are psychological (mental) events which are not at the same time physiological events. The psychological and physiological events are two aspects of the same unitary process. The exact form into which the essential unity of psychological and physiological events is cast varies from one psychologist to another. The two most prominent forms are psychophysical parallelism and psychophysical isomorphism.

However, there are a great many events, of interest to psychologists for which only the psychological aspects are known. When we discuss the relations between these events and ones for which both aspects are known or ones which are purely physiological, with no phenomenological or more broadly psychological content, it may appear as if we are espousing an interactionist view of the relation between mind and body. This danger is probably most severe in the areas of psychopathology when we discuss the genesis of hysterical or psychosomatic symptoms. The layman often interprets psychologists' descriptions in this area as examples of the power of the mind over the body. And in truth it must be admitted that some researchers and clinicians in the area do not do much to dispell the misunderstanding.

If one holds to Hebb's view that mentalistic intervening vauables are at best to be tolerated until we know more about the neurophysiology of thought and perception, the study of the latter two as areas of primary interest would eventually disappear. If we could trace every neural event between the exposure of a stimulus on a screen and the muscle movements involved in the production of a specific vocal response, measured in terms of frequencies and amplitudes of sound waves, Hebb appears to believe that all possible psychological questions will have been answered. This is certainly the point of view taken by F. H. Allport (cf. earlier readings) and by many psychologists. Given this point of view, the experiences of the subject which may have occurred along with some parts of the neurological sequence are unimportant by-products or epiphenomena. Since in this golden age of the future these epiphenomena might still be difficult to measure so that there would seem to be little reason for paying scientific attention to them.

If, on the other hand, we hold that the phenomenological or meaningful aspects of events occuring in an organism are just as much a part of the events as the physiological aspects, then a rather different kind of possibility opens up. We might progress very far in the psychological measurement techniques we use to infer the state of the psychological aspects of organismic events. We also might progress very far in the development of theories relating these psychological aspects to the behaviors they determine. If this were to occur, we would be able to make very sound predictions of behavior from a knowledge of the environment of an organism and its relevant past experience or its current psychological state. Nothing but the limitations of our measurement techniques and theoretical creativity stand in the way of reaching this non-Hebbian golden age of psychology.

To be sure we are very much more in the dark ages with respect to psychology than with respect to physiology. Although this point has been mentioned before, it is still worth repeating that despite its current benighted state, psychological knowledge provides a much firmer basis for the prediction of behavior than physiological knowledge. The physiological theories that have been put forth to account for the regularities we observe in behavior are not based on observable neural events, but on hypothetical extrapolations of these events. This is as true of Hebb as it is of Köhler. Indeed, after writing his influential book, Hebb wrote an article in which he discussed the C.N.S. (the standard abbreviation for the Central Nervous System, i.e., the brain and spinal cord) as the "Conceptual Nervous System."

Where does this leave us? In practice it leaves us close to where Hebb really is. He is a very tolerant gentleman and is willing to make use of any kind of data he can get in order to understand how behavior is determined. We can speak of anxiety producing excessive secretions of stomach acid, if this helps us to spot and treat potential ulcer patients. We can do this as long as we realize that what we really mean is that event A, whose psychological aspect is anxiety and whose physiological aspect is unknown leads to the exessive secretion . . . etc. We can talk about a motive or expectation affecting the probability of making a specific recognition response. If some of you find it useful to translate the term expectation into a partially activated neural structure known as a cell assembly, go right ahead. You will be none the worse for it, as long as you don't deceive yourself. Indeed in the end the psychology of perception might be better off, because the translation might stimulate physiological research that will round out our knowledge of the processes which intervene between stimulus and response.

Chapter 1.

1. What does Hebb mean by the sensory dominance of behavior? What observations lead him to reject the notion?

2. What significance does Hebb draw from the electrophysiological evidence (e.g., brain wave recordings - EEG and direct recording via electrodes implanted in the brain)?

3. "Synchrony of firing" refers to a number of cortical neurons firing regularly and in unison. This would be necessary to generate an electrical field in the brain sufficiently powerful to be picked up by electrodes attached to the skull.

4. A critical phrase is "sensory activity is essential to the regulation of neural firing, but not essential to initiating it." The discoveries of the activating function of sensory imput to the cortex coming through the ascending reticular formation (cf. Krech and Crutchfield, Chap. 7) has forced Hebb to change this view. External stimuli can activate the cortex, as can internally produced excitations from other parts of the body through their effects on reticular activating system. Indeed one neural event in the cortex, can excite the reticular system which in turn increases the general level of cortical activity. In this way we can see a possible physiological aspect to general motivational arousal produced by an external object, e.g., a shapely coed, by internal stimuli, e.g., pain, or by an idea. All of this doesn't deny Hebb's point that much cortical activity is independent of specific sensory inputs.

5. What is the dilemma involving the physiological aspect of memory? Why are each of the two major physiological schemes, proposed so far, inadequate?

Chapter 2.

1. What is the distinction between primitive and nonsensory unity according to Hebb? How is it related to his criticism of Köhler?

2. What kind of instability in the perception of clear figures is overlooked by the Gestaltists, according to Hebb? How is this related to the difficulties we encountered in getting some of our Gestalt demonstrations to work?

3. What does Hebb mean by "identity?" What relation does it bear to generalization, memory and meaning?

4. Hebb mentions that Gestaltists have not recognized the distinction between figural unity and identity. This is not correct. Koffha clearly distinguished between figural unity, (segregation of figure from ground) and identity (perceived shape). However, it is true that Gestaltists explained both in terms of field dynamics.

5. What two types of evidence does Hebb cite to support his view of the distinction between figural unity and identity?

Chapter 3.

1. This chapter returns to the dilemma presented in Chapter 1 and discusses the neurophysiological alternatives in more detail.

2. What meanings does Hebb give to the following terms?
   equipotentiality, configuration theory, sensory equipotentiality, equivalence of stimuli.

3. Remember Hebb's brief description of Marshall and Talbot's view of how differences in overall intensity levels of retinal stimulation are decreased as we proceed from retina to visual receiving area of the cortex. We will meet a theory, later on this semester (viz. Helson's Adaptation Level Theory) which may be relevant to this process.

4. Why is the fact that a rat can transfer a response, learned to a small square, to a situation involving a large square not necessarily evidence for sensory equipotentiality?

5. In reading, the experimental and clinical evidence brought by Hebb against sensory and cortical equipotentiality, be sure that you see the relevance of each datum he presents. (Some of the data are directly relevant to questions raised in class about Gestalt perceptual theory.)

Chapter 4.

1. What are the two kinds of traces mentioned by Hebb?

2. What is the basic neurophysiological postulate introduced by Hebb? It is important to note that the postulate might be correct without the specific mechanism proposed by Hebb (growth of synaptic knobs) being responsible. Indeed, there have been other specific mechanisms proposed.

3. In figure six, the gray areas represent cell bodies while the black lines represent axons and synaptic knobs.

4. Areas 18, 19, 20, are stripe shaped cortical areas running parallel to the border of the two areas 17; (one in each hemisphere of the brain) they are often referred to as the visual association areas. Contralateral means on the opposite side of the brain; ipsilateral means on the same side.

5. Be sure to work through the firing diagrams in the various figures presented by Hebb in this and the following chapters.

6. What is it about the cell assembly that enables it to remain active for periods longer than those involved single chain reverberatory neural circuit? What is the event most likely to disrupt the firing pattern in a lattice of cells in areas 17, 18, 19 and 20?

7. Why does Hebb stress the enormous complexity of the network of axons?

8. What is the relation between the size of a cell assembly and its ease of being associated (connected) to another cell assembly? What does Hebb say is responsible for this relationship?

9. Why would time be an important factor in the development of stable cell assemblies?

10. How does Hebb distinguish between the type of learning that takes place early in an organism's life and the kind that takes place later on?

Chapter 5.

1. What is the relation between Hebb's point of view and classical structuralism? How is it similar, how is it different?

2. In reading Hebb's discussion of the importance of contours, recall the demonstrations indicating the primary importance of contours in maintaining the perceptions of figures. Remember too the importance of contours and angles as measures of figural complexity.

3. What is the relation between contours and eyemovements? How does Hebb explain the tendency to fixate angles and line intersections? (Once again recall Hochberg et.al., discussion of high informational content of angles.)

4. Note that the cell assembly, referred to the previous chapter refers to a structure growing out of a single fixation, i.e., a stationary eye.

5. What are the neurophysiological aspects of expectancy (set) and attention in Hebb's theory?
(Note: he treats this point in more detail at the end of the chapter.)

6. What are the two reasons given by Hebb for the likelihood that the cell assemblies corresponding to the separate angles of a triangle are less likely to involve the same cells during the initial stages of learning to perceive a triangle?
(Note: the process of fractionation is involved.)

7. How does Hebb account for the generalization of learned responses from figures of one size to those of another size?

8. How might Hebb's theory be used to explain the fact that it is easier to get a rat to learn a visual pattern discrimination in a Skinner box than in a jumping stand?

9. What finally is responsible for bringing cell assemblies together into a temporally unified pattern (superordinate structure)?

10. What is a phase sequence? How is it related to the cell assemblies and the unified pattern referred to above?

11. Problems with "t". First, the conditions leading to fractionation (see question 6) appear to be very similar to the formation of "t," yet fractionation and the formation of superordinate structures appear to be opposite problems. Second, why shouldn't "t" persist, considering Hebb's statement that the average value of the eye-movement vectors included in "t" is zero?

    Both of these questions probably can be answered satisfactorily, without altering Hebb's ideas.

12. Assuming you have solved the problems just mentioned, how might Hebb explain our observation that one way of getting a reversible figure to "flip" is to shift the point of fixation?

13. Remember that Hebb's theory relies upon conceptual not observational neurology, although the former is more consistent with observation than is the Gestalt conceptual neurology. It is possible to recast his model into purely abstract terms and simply deal with sets of elements (sensory, ideational and motor) which become associated when

appropriate types of experiences occur. (See H. Peak, Psychological structure and psychological activity. Psychol. Rev., 1958, 65, 325-346 as an example of such an abstract structural model.) This is not to deny that the facts of neurophysiology played a part in Hebb's creative activity. It is merely to state that they may not be necessary. Indeed treating a cell assembly as a set of abstract elements might facilitate the application of mathematics to the description of the learning process. (Such attempts have been made.) To wrap things up one might observe that many neurophysiologists use abstract mathematical elements and functions to describe the operation of the nervous system.

Dember, W. Psychology of Perception, Chap 2, Part II, pp. 12-26.

1. The first paragraph in this section is an epigrammatic statement of some of the major substantive and methodological problems in perception.

2. What is meant by a perceptual task? What are the perceptual tasks discussed by Dember?

3. What is Dember's view concerning the distinction between absolute and difference thresholds?

Chap. 2, pp. 27-60.

1. What is Dember's definition of a threshold?

2. What problem arises in the measurement of thresholds because of the fact that subjects may never respond correctly at precisely the proportion specified in the threshold definition? Why is this a theoretical as well as a methodological problem?

3. What is an indicator response?

4. What important difference makes the forced-choice indicator generally preferable to the yes-no indicator in the measurement of detection thresholds?

5. Dember's discussion of Tanner and Swets anticipates some of what you will be reading in this unit. It actually should not have been included in a discussion of thresholds because as you will learn, Tanner and Swets reject the threshold concept.

6. What are the advantages of the yes-no response indicator?

7. What is the difference between the constant stimulus method and the method of limits?

8. What are the two steps involved in Quadrant II threshold assessments?

9. What steps are generally taken when using the method of limits to control for the effects of sequential presentation of stimuli?

10. The comparison of methods used with humans and animals is instructive because of the light it sheds on the behavioristic way modern psychophysicists deal with their subject matter. Essentially they are interested in differences in behavior, not differences in experience. This discussion also points to the ubiquitous problem of the validity of perceptual indicators.

Chap. 4.

The material in this chapter is not directly related to our major interest in this unit. Rather it presents some of the information that has been obtained using psychophysical methods. This research area is sometimes called sensation; it represents an unbroken line of inquiry that gathered momentum early in the 19th century and was taken up by the "new psychology" of Wundt, et al.

Galanter, E. Contemporary Psychophysics, in New Directions in Psychology I, pp. 89-114 - Introduction and section on detection.

1. With what type of unit do we measure thresholds? What type of data is used to determine threshold values?

2. How does Galanter propose we measure response strength? What other measures have psychologists used to measure this variable? (Note: the answer to this item must be culled from your general background in psychology.)

3. How can we alter the value of the detection threshold without changing the intensity of the stimulus being used or the sensitivity of the observer?

4. What is an iso-sensitivity curve? (Note in later readings, the cruve sill be called a response operating characteristic.) How does one obtain the data needed to plot such curves?

5. What is a pay-off function? (Note: the tabular presentations of such functions, as on p. 106, are often called pay-off matrices.

6. What is meant by response bias?

7. What is meant by noise in detection experiments?

8. Galanter's statement about the lack of knowledge about the interactive effects of backgrounds, stimuli (p. 110) is more extreme than is warranted. In fact it is downright false. It ignores the contributions of Gestalt psychology and also the contributions of some modern psychophysicists whom we will study later.

9. Study Fig. 6; it is an important schematization. We will discuss one very much like it later this semester.

10. There is a printer's error in Table 7. The 2¢ in the lower right corner of the matrix and the 10¢ above it should be excahnged.

V. A 2. Swets, J. Is there a sensory threshold?

1. How did Fechner and his descendants account for the fact that a faint stimulus of a constant intensity might sometimes be detected by a single subject and sometimes missed?

2. What does Swets mean by the observer's response criterion in the method of limits? How is it related to variation in measured thresholds?

3. What two variables are confound when thresholds are assessed by the method of limits?

4. What is Swets' hypothesis regarding sensory thresholds?

5. The quotation from Boring is wrong in at least two respects. Swets uses it merely to indicate the position he wishes to refute.

6. What is "the fundamental detection problem"?

7. Is the observer in Swets' basic detection situation dealing with experience in an immediate or mediate fashion?

8. What does Swets mean by sensory excitation? What else besides sensory excitation is involved in determing whether an observer reports that a stimulus is present?

9. **What produces variation in sensory excitation when the** same physical stimulus is presented at different times?

10. What two probabilities must the observer consider when he is trying to decide whether a signal occurred during a time interval?

11. What is the likelihood ratio referred to by Swets? What part does it play in the observer's decision about whether or not a stimulus was presented during some specified interval?

12. What is the relation between a response criterion of an observer and a likelihood ratio?

13. When Swets speaks of inducing observers to change their criteria from one set of trials to another, he should say how this is done. There are two basic methods; manipulating rewards for hits and misses and probabilities of signal occurrence. Both of these are discussed in the Galanter reading.

14. What is the operating characteristic curve? (See Fig. 1 for an example.)

15 According to Swets' theory what determines the shape of curve?

16. What is the relation between operating characteristic curve and the criteria used by observers?

17. What is the meaning of the two bell shaped curves in the lower right hand parts of the operating characteristic curves?

18. What is d'?

19. What was the procedure in the experiment whose data are presented in Fig. 2? What implications does Swets draw from the results?

20. What was the procedure in the experiment whose data are presented in Fig. 3? What implications does Swets draw from the data?

21. What does Swets mean by the experimental invariance of d'?

22. Compare Swets' explanation of variability in an observer's accuracy of detection of signals of a given intensity with the classical explanations. In what way is the following statement true? "What was constant for the classical theorists is variable for Swets and vice versa.

23. Don't worry about $(2E/No)^{1/2}$; I don't know what it means either. You can understand what Swets is saying without deciphering the symbol.

24. What value does Swets see in the theory of ideal observers?

25. Note a psychometric function is simply a plot of an observer's correct detection responses against the intensity of the stimuli he is shown. When this is shifted to the right, it means that the observer must have a more intense stimulus in order to achieve a given level of accuracy than would be the case with an ideal observer. The steeper the slope the more rapid the rate of increase in detection accuracy as intensity increases. Both of the departures of obtained from ideal psychometric functions can be attributed to difficulty with very faint stimuli. The answer to the next question states why observers have trouble with faint stimuli.

26. What does Swets believe is primarily responsible for human observers falling short of ideal performance?

27. Blackwell's theory is the one presented by Dember. Swets' equation (2) is the correction procedure Dember gives. Dember was a student of Blackwell at the University of Michigan, Swets, Tanner and Green were also at the University of Michigan at the same time. There was lots of lively discussion among them.

28. Don't worry about the other threshold theories described by Swets. They are important, but you can't be expected to learn much about them from Swets' brief presentation. The important point is that there are a variety of formulations which can be applied to what was once thought to be a simple situation. All of them are rather sophisticated mathematically.

29. What implications does Swets believe his data have for how we ought to measure thresholds? How is this related to Dember's discussion?

Miller, G. The magical number seven, plus or minus two: some limits on our capacity for processing information. B & W pp. 90-114

1. What is the relation between information (as used in information theory) and variance?

2. How might the correlation coefficient statistic be used to measure the performance of a communication system?

3. What is meant by absolute judgment? We shall treat this topic in considerable detail later on.

4. What does Miller mean when he says that the channel capacity of a listener for absolute judgments of pitch is 2.5 bits.

5. What is the effect on channel capacity of increasing the number of dimensions along which stimulus inputs might vary.

6. When we reach the capacity of a channel for the simultaneous transmission of information from some set of potential events, how can we change our mode of communication so that we increase the total amount of information transmitted.

7. What difference has been observed between the span of absolute judgment and the span of immediate memory?

8. What is a "chunk?" How is it formed? How is it related to difference referred to in the previous question?

Broadbent, D. Perception and Communication

With Broadbent's work, we touch upon a very important area, viz., the perception of speech. This work stems originally from the interest of telephone engineers in improving the efficiency of their communication systems, but its theoretical implications are also quite important. The chapter summaries which have been assigned are intended to inform you about the nature of the research that has been done and to help you in reading the full length chapter assignments. It would not at all be out of order for you to read the remainders of the chapters whose summaries are assigned.

Chap. 2 Summary

1. A frequent opposition made in psychological theories is the one between central and peripheral determinants of phenomena. Peripheral explanations are generally regarded as desirable because we know more about what happens in the sense organs and muscles than we do about what heppens in the brain. It is therefore customary for the proponents of antralist explanations to take some pains to show that the phenomena upon which they focus could not possibly be explained peripherally.

2. Is it correct to say that we cannot attend to two messages at once? Why?

3. How is Broadbent's conclusion related to the problem discussed in the reading by G. A. Miller?

4. What alteration would Broadbent make in the traditional behaviorist definition of the term stimulus? (Cf. the next chapter for more information relevant to this question)

Chap. 3

1. What relation is to be inferred between the number of discriminations an organism can make and the nature of the related neurophysiological processes?

2. Broadbent's discussion in the first few pages of this chapter is equivalent to Miller's discussion in his article?

3. What phenomenon in visual perception is analogous to the observation that when a difficult and an easy message compete for attention, the easier message suffers more than the difficult one.

4. How does Broadbent explain the tendency to select messages on the basis of simple physical qualities, e.g., pitch, ear through which message is received, etc.

5. What is the meaning of the diagram on page 43?

6. What implications does the diagram have for the demands made by different tasks upon information capacity?

Chap. 4 Summary

1. What correspondence does Broadbent see between the effects of increasing the amount of information in a task and of increasing the fineness of the descriminations which must be made?

2. After this chapter, Broadbent leaves the speech situation to study problems involving attention and information capacity with other stimuli.

Chap. 5 Summary

1. What does Broadbent appear to mean by filter bias?

2. Compare his filter biasses with the determinants of attention discussed in connection with Titchmer's view of attention.

3. Bessure that you understand the common strand running through the topics at the end of Broadbent's summary.

Chap. 6

1. Mark well the few sentences on the value of applied research. This is a view which is sorely neglected by most academic psychologists. We will return to it in our discussion of Brunswik's view of psychological research.

2. Remember Mackworth's clock task; it is referred to quite frequently in the vigilance literature.

3. What conditions have been found that reduce the decrement in accuracy during the course of long vigils?

4. What has usually been found concerning the effects of signal intensity and duration in a vigilance task?

5. It would be wise to remember the variables which have been studied in relation to vigilance behavior.

6. How does Broadbent try to explain vigilance decrement?

7. What is the inhibition explanation of the vigilance decrement? (Note this is similar to the fourth view mentioned in the lecture notes; however it is based on a classical rather than an operant model.)

8. What evidence does Broadbent offer against the inhibition view?

9. What is the significance of experiments in which the mean inter-signal interval is held constant but the variance among the intervals is varied?

10. Which aspect of vigilance performance is handled well by expectancy theory, which is handled poorly?

11. What observations are seen by Broadbent as embarrassing to the activation theory of vigilance behavior?

12. What is the distinction between paced and unpaced performance tasks? How does behavior differ in these tasks? How are these different behaviors believed by Broadbent to result from the same process?

13. What relationship does Broadbent propose between blocking and the operation of the filter?

14. What are the two aspects of behavior in the vigilance situation with which Broadbent's discussion is most concerned?

15. Which of the aspects, referred to in the previous question, is best accounted for by filter theory? Which theories do best in accounting for the other aspect?

16. How does Broadbent combine the several theories to account for both aspects of vigilance behavior?

Chap. 9 Summary

1. It appears as if one of the major functions of perception is to prepare inputs for storage in memory. In this sense perception is clearly more than an epi-phenomemon. It has also been suggested that the clarity of the perceived material will affect the nature of the long term storage. Stimuli at the periphery of attention may be stored in accordance with principles which differ from those governing the storage of information at the focus of attention. This distinction, although far from proven, has been used by psychoanalytically inclined students of perception and cognition to explain some possible effects of peripheral stimulation on fantasy, dreams, etc. We will have more to say later about this and about the general relation between perception and other cognitive processes, viz., memory and thinking.

McGrath, J. J., Irrelevant stimulation and vigilance performance.

This series of 3 simple experiments are direct tests of derivations from two vigilance theories, Broadbent's filter theory and arousal theory. The first two are designed on the assumption of an opposition between the two views of vigilance. The third combines the two views. Perhaps the most interesting general point to be made about the studies is the importance of looking carefully at the procedures of a study before accepting its conclusions. Sometimes experiments, purportedly designed to test a theoretical derivation, produce negative results which stem from improper translation of theory into operations rather than because of flaws in the theory.

1. What effects should arousal theory have predicted concerning the effects of monotonous versus varied extraneous conditions in all of the experiments? What was the rationale of this prediction?
2. What was the prediction derived from Broadbent's theory in the first two experiments? Why were these experiments inadequate tests of the theory?
3. What was the prediction in the third experiment? What was its rationale?
4. Why, in the second experiment, did the difference between the album and control condition decline as the watch progressed?

Jerrison, H. and Pickett, R., Vigilance: A review and re-evaluation. (Reprint)

This review is assigned for two reasons. First it represents still another theoretical approach to the area. (It does seem peculiar that such a simple situation can elicit so many complicated theories.) This is an important approach because unlike the others, it is based on decision processes. It derives most immediately from signal detection theory. However, the decision model, as has already been noted, is applicable to areas of motivation, social interaction, to areas involved in the more macroscopic social sciences of sociology, economics and political science and to the new technology of operations research. (It is somewhat interesting to note, in this connection, that the political scientist who studies strategic decisions in national policy making, the operations researcher who studies the organization of military, man-machine systems and the psychologist who studies the G.I. who is trying to keep awake as he looks at a radar screen may all be using the same decision model in their theories.)

The second reason for the assignment is that it provides a well organized, up to date description of theories, data, and applications. You are required to read only the theory and a small part of the data section.

1. The analysis of a generalized task into its components is a standard starting point for operations research. It is analogous to the analysis of routine mathematical operations into their basic arithmetic and logic components that occurs in computer programming. Of particular importance here is the distinction between orientation movements and observing responses. It is the failure to accept this distinction leads to criticism of Skinnerian analyses of vigilance behavior (Cf. Jerrison and Wing, in Buckner & McGrath, Vigilance a Symposium, pp. 28-43.) Observing responses correspond to the central aspects of paying attention.
2. What distinction do the authors make between detection studies and vigilance studies? What plays the same role in vigilance that decisions about the possible presence of a signal play in detection?
3. Do not be misled by the acknowledgement of Holland's work by Jerrison and Pickett. They may have been stimulated by his work, but they disagree in an important way about the nature of observing responses. (Cf. comment No. 1, above.)

4. What is the basis on which observer makes decision of whether or not to observe?
5. What assumption is generally made about false alarms in the vigilance situation?
6. What is the role of signal strength in vigilance? Why do the authors feel it is necessary to discuss this role?
7. In the little paragraph preceding the section on a numerical example, the authors indicate the abstract hypothetical nature of the observing response. It does not necessarily correspond to a single physiological event; it may correspond to a sequence of discreet events. All that they assert is that whatever the physiological basis of what they call observing responses, these can be treated as if they constitute a single process, which can occur with varying degrees of strength.
8. The expected value equation, EV= (probability of an event) X (utility event), used by Jerrison and Pickett is the standard one. As they note, the utility term is the tough one to operationalize.
9. Even though they cannot measure utility of spotting the event for which the vigil is kept, they do make an assumption about changes in this utility during the course of the vigil. Why do they assume this?
10. What parallels do the authors see between their theory and other theories?
11. What assumptions does Holland make in order to apply the operant approach to vigilance? It may seem peculiar for a radical behaviorist to study a perceptual process. Perception generally implies experience, consciousness, etc., and these are not believed by behaviorists to be amenable to study. This apparant problem is overcome by redefining perception to mean overt response. This redefinition allows some interesting behavioristic studies to be done in situations normally used in perception research. Much of the current work in the old area of threshold assessment and observer accuracy are done from this new point of view. Some of these studies may have so redefined perception that it ceases to exist as an area which is separate from the general study of behavior (e.g., operant conditioning). Others, like Jerrison's, appear to overlap the concerns of traditional students of perception. However, it should be clear that Swets*et.al*., Jerrison and others are indeed behaviorists. They do not attempt to measure or make statements about experience.
12. What theoretical significance do the authors attribute to the fact that illumination responses must be hard to make in order for Holland's results to be repeated? Is there anything in the work on operant conditioning which leads one to expect this result? Could it be that all operant phenomena can be understood as the outcome of decision processes.
13. In this section it is important to recognize that Jerrison and Pickett are saying that observing responses are operants and therefore respond to experimental variation in the same way as Holland's illumination responses. They are not saying that observing responses are synonymous with illumination responses. As was mentioned earlier, the latter fall under the heading of orientation responses.
14. Why should weak signals, which are still strong enough to be reported at high levels of accuracy in alerted observers, lead to sharper vigilance decrements than strong signals? Use the decision theory to answer this question.

**Jerrison, H. and Pickett, R., Vigilance: The importance of the elicited rate. Reprint**

This article follows the decision making view of decision decrements. It can also be seen as relevant to the role of expectancies and operant phemonena in vigilance. As you will recall both of these have been incorporated into the decision approach. Note that this study uses the kind of vigilance situation in which non-signal stimuli are presented regularly and the signal is simply a variation of the non-signal stimulus. In this respect it is rather different than the tasks which resemble the monitoring of a radar screen.

1. What was the independent variable in this study?
2. What were the results and how were they explained?
3. How would Broadbent's filter theory account for the findings?

# Reading Notes

Eriksen, C.W. , Discrimination and learning without awareness: a methodological survey and analysis.(Bobbs-Merrill Reprint from Psychological Review, 67, 279-300.

## Background

Charles Eriksen was trained as a clinical psychologist at Stanford University. His early research was in the area of the effects of psychological defenses on the recognition of anxiety arousing stimuli. From Stanford he moved to Johns Hopkins and into a department noted for its rigorous quantitative and psychophysical tradition. His orientation in this atmosphere underwent a drastic change. With the exception of some studies in general judgmental processes, his work in the past dozen years has been directed at debunking poorly done and carelessly conceived experimental work, purporting to show some effect of unconscious processes, psychological defenses, etc. in perception. Although he may be a bit too sweeping in his criticism, generally his ideas and work are very sound and deserve careful attention.

## Questions and comments

1. What is the usual operational definition of awareness, in the studies considered by Eriksen?

2. What are some of the shortcomings of verbal indicators of awareness?

3. What are the two questions that can be raised concerning discrimination without awareness?

4. What is it about responses to meaningful stimuli/which makes it unlikely that we can respond emotionally to a stimulus before we have enough information about to identify it?

5. What is meant by subliminal conditioning?

6. What is Eriksen's criticism of Taylor's experiment in which subjects were conditioned to make a GSR to a geometric figure presented below its identification threshold?

7. What problem is there with the Newhall and Sears data, which showed that a finger retraction response could be conditioned to a light at the absolute threshold, conventionally defined?

8. What is the implication of the threshold value obtained by Newhall and Sears using their conditioned response rather than a verbal response?

9. What are the implications of the threshold data in the Dulany and Eriksen experiment in which thresholds obtained using GSR responses were compared to thresholds obtained using two verbal report methods?

10. Eriksen's description of the study he did with Dulany may be a bit misleading, and will therefore be described in a bit more detail here. They used a two alternative forced choice indicator response, a yes-no indicator, and what amounts to a GSR forced choice indicator. To accomplish the latter, they conditioned the GSR to a light, by pairing the light with an electric shock, in the classical procedure. Once the conditioned response reached a criterion they measured the threshold by exposing the light during one or the other of two consecutive time intervals. The time interval which had the greater GSR, was taken as the one in which the GSR indicated the signal had been received.

The results of the study indicated clearly that the verbal forced-choice was more sensitive to the presence of the light, i.e., produced more hits than the GSR, holding the number of trials with each method constant. The GSR forced-choice response was more accurate than the yes-no response indicator. However, a direct comparison can't be made between the yes-no and GSR indicators because the latter was a forced-choice procedure and the former was not. It is difficult to see how one could use the GSR in a manner analogous to the yes-no response unless one selected an _a priori_ criterion which the GSR had to exceed before it would be considered as having indicated receipt of the signal. It might also be possible to use the GSR rate during catch trials as a baseline and consider any GSR which departed significantly or by some pre-determined amount from the baseline as equivalent to a yes response.

As we will note below, it is not clear that the forced choice response is appropriate to the problem of discrimination without awareness and therefore the use of the GSR in the forced choice paradigm might not provide the damning evidence Eriksen appears to think it does.

11. What new kind of analysis did Eriksen perform in his replication of the Lazarus and McCleary study?

12. What are the three possible relationships between the percept, GSR and verbal response considered by Eriksen? Which does he believe is correct? Why?

13. A partial correlation is the correlation between two variables, holding a third variable constant. It is performed to see if the correlation between the two variables is independent of the third or whether it is a spurious consequence of variation in the third.

14. Eriksen makes a mistake in his description of Dixon's procedure; Dixon used a descending method of limits. He started with the line clearly above threshold and reduced its intensity until the observer said he could no longer see it. This is likely to give a lower estimate of the threshold than doing it the other way around because the observer knows what he is looking for.

14. What data did Fuhrer and Eriksen obtain indicating

that Dixon's explanation of his data was incorrect? What was the explanation advanced by Eriksen and Fuhrer?

15. Eriksen's dismissal of the studies concerning ratings of subjective confidence makes for great difficulty. If we want to know whether an observer is aware of a stimulus, we must look at a response which indicates that he is aware, not any old response. Eriksen would have us accept the production of any verbal response to a stimulus in a discriminative fashion as evidence of awareness. But this is assuming an answer to the very problem we wish to investigate. By definition, correct forced choice responses that are significatly related produced at a rate significantly better than chance are evidence for awareness. If Eriksen is correct in rejecting observers' reports about their awareness, then he ought to conclude that the problem is insoluable, rather than concluding that there is no evidence for discrimination without awareness.

Eriksen may not be justified in brushing aside phenomenological reports so easily. We ought to apply the same criteria to judging the adequacy of these responses as we apply to the judgment of the adequacy of any other responses, namely:

a) Is the response capable of conveying information about the aspect of the percept in which we are interested? For example, can we rely upon a language which has only two words to describe color as an indicator response in the study of color vision? Obviously not; the percepts we wish to study are too complex to be coded accurately into just two categories. Eriksen is quite aware of this criterion; he mentions it on p. 291 in his discussion of response bias. The appropriateness of the response system we allow the observer to use is not merely a matter of the number of categories. The content of the categories is also important. If we want our observer to tell us about color, but don't allow him to use color names, he will not be able to provide the information we wish.

b) Does the observer know how to use the response system we make available? For example, asking most people to draw what they see when exposed to a Rembrandt painting is likely to provide us with relatively little information. Similarly, asking children to draw what they see and then taking the drawings as evidence for the peculiar, unorganized nature of children's percepts is an inadmissable procedure.

c) Closely related to the previous point is the question of whether the oberver and the experimenter mean the same thing by the language being used to describe a percept. This question can never be answered with complete certainty in perception or in any other area in which people communicate to one another. Nevertheless some precautons can be taken to rule out gross misunderstandings.

d) Is the observer motivated to use the response system as accurately as he can?

Using these criteria, it is clear that the forced choice response system and the yes-no response system have serious drawbacks. The former is simply not relevant to the question of whether the observer was aware of a stimulus. The data it yields can answer the question of whether the observer can respond differentially to the stimulus, but the observer need be no more aware of his differential response than he is of his pupillary adjustments to lights which vary in intensity. The forced choice response is not able to provide positive or negative evidence concerning the observer's awareness.

The yes-no response is oriented toward the aspect of perception we wish to know about when studying the problem of discrimination without awareness or subliminal registration, as it has sometimes been called. Unfortunately, it is too gross to be a very accurate indicator. It is very much like our two word color vocabulary being used to convey a person's experience of all the hues in the spectrum. There are many states of awareness or levels of awareness between that which we find when we focus on a clearly illuminated stimulus and when we are presented with a subthreshold stimulus off to the side while we are concentrating on something else, perhaps in another modality. Too little attention has been paid to developing differentiated response systems to handle the complexity of the aspect of perception we wish to describe. The closest we have come are the very set of responses Eriksen wishes to discard, namely ratings of confidence in our yes or no report.

There seems to be no reason preventing this system from being developed to a point where it satisfies our criteria. Subjects could be trained to use the response in the same way that they are trained to use any rating scale. We would give them experiences drawn from all parts of the continuum we wish them to describe, and give them feedback about the stimulus which was presented after they describe it. Once we we get the observer to use the response in a manner which is correlated with the stimulus variation, e.g. a gradual increase in certainty as the intensity of the stimulus is increased and close to zero certainty when giving false positive or false negative responses, we could use the response like any other. Swets has used such a response and has shown that it can generate the kind of relationship with stimuli just described. The training of observers in psychophysical studies is a standard procedure, even with forced choice response systems. With these latter systems, one of the things accomplished in training is to get the observer to keep trying even though he sees nothing, i.e. claims he is aware of no stimulus. Naive observers get discouraged under these circumstances and begin to make random or systematic guesses, which are not a function of sensory processes but of some hypotheses they have concerning what the experimenter is likely to do or, when matters are really bad, a function of a diabolic scheme to louse up the experiment.

The final comment on Eriksen's criticism of confidence judgments is his apparant assumption that all observers should be aware of a constant stimulus intensity to the same degree. (p.293) This is not reasonable. Just as observers have different detection sensitivities,so too they might well have different awareness reactions to the same stimuli. Indeed individual differences in what Eriksen calls criteria for awareness might be a very fruitful area of study, especially for psychologists interested in personality.

16. The Klein group has done the best work in this area. Some of their studies will be reviewed in class. We will soon have the equipment to carry out this kind of study using metacontrast.

17. What is the flaw in the Shevrin and Luborsky study on subliminal effects upon dreams and images?

# Appendix II

## Selected Comments from Student Course Evaluations

1. General comments on notes and demonstrations.
2. Comments on specific notes and demonstrations.
3. Comparison of new and conventional parts of the course.
4. Criticism of notes.

GENERAL COMMENTS ON NOTES AND DEMONSTRATIONS

"I felt that the availability of lecture notes and reading questions for use in conjunction with reading was very helpful. It made me a little better able to bring up difficult points in class -- and to gave more time in class to discuss them."

"So far the overall class plan of plentiful demonstrations and discussion of them, combined with discussion of the readings has been very successful. It strongly reinforces the materials in the readings and gradually builds up a clear understanding of the theoretical positions involved and the relation of the experimental work to the theoretical bases. The handling of the experiments to point out the weaknesses and inconsistencies of the theoretical base was extremely valuable in that first, it prevented the assumption of theoretical absolutism, and at the same time showed how it is possible to go about attacking a theory through experimental means. The demonstration of the means of editing lines of research and specific problems in order to preserve a theoretical position was also an enlightening lesson."

"The most unfortunate aspects of the demonstrations was that they sometimes failed to demonstrate the phenomena that they were supposed to. Even when this happened, they were extremely helpful and play a very important part in the course."

"It is difficult to evaluate the class demonstrations as a whole because I felt they ranged from excellent to poor. The Ganzfeld and the rotating trapezoid I found to be particularly worthwhile because they illustrated phenomena which are difficult to conceive of without first having experienced them. As I recall, I did not find some of these during the Gestalt section as worthwhile.

I found the class discussions to be the best part of the course. Those days of embarassing silences when nobody had made it to the reserve room were more than compensated for, I felt, by those occasions when the assignments were completed. I thought we went into some of the experimental evidence in such depth that often I really got a feel for what was known and what methods could be used to test some of the propositions. I think that my own ability to criticize some of the research was strengthened by this.

I have mixed feelings about the experiments we did. Sometime between the initial idea and the final execution and write-up something changed. My interest lagged, the experiment dragged on. I learned that the difference between patience and a sense of futility was entirely subjective: that I could patiently try various combinations of designs until I stumbled upon the correct method because the experiment was due in a week and I, therefore, would discover some way to test my hypothesis within that week. Futility was there, also, however, the numb feeling one gets while banging one's head against a wall. I did learn that conducting experiments was not the easiest task in the world, that the theoretical difficulties are more than matched by practical problems such as getting your subjects to respond the way you want them to. Many times I wished my subjects had been rats rather than Haverford students."

"I felt that your written explanations and comments on the reading were very helpful. I found it most useful to use them as a supplement and review of the reading after it had been done. The questions were a good test to see if I had recognized the different problems discussed in the reading. I got a lot more out of the part of the course that was taken at a slower pace than the latter part that went quickly. I noticed that you showed concern that you had lightened the work load in parts of this course. I don't think you should worry about having done this. Perception is the first course that really showed me the benefits that Haverford can offer. Of course the small size of the class helped make discussion better. However another factor that contributed to the quality of the discussion was the fact that we had time to really think about what we were reading. We also thought about it with the idea in mind that we were going to have to discuss it the next day. This attitude plus the actual discussion made the course better.

I'm not really sure how helpful the demonstrations that we were shown were. They did make the phenomena we were studying more clear than they would have been if we hadn't seen them. I did notice sometimes that I did have trouble imagining what the reading was discussing until I saw it."

"Demonstrations, personal experience with the phenomena, and individual projects are perhaps more valuable in this course than in any other. Since all of us have done a great deal of perceiving in our lives, we are at least somewhat qualified and capable of having insights into "what is really going on" and resulting opinions of the validity of proposed theories. Discussion is a vital aspect of this course as are demonstrations and projects. The "lab" period is an excellent way of supplementing the regular class periods. In the parts of the course which lend themselves to demonstration, I think the best method of teaching is to have the student (who has done the reading) observe the phenomena, and then try to explain it in terms of the reading. There is no better way to insure an understanding of the material. Also, to try to conceive of experiments which could be done to prove or disprove an hypothesis is excellent and necessary preparation for the psychology student."

"I think the question sheets in the beginning of the year were very valuable, and though it means a lot of work for you, it would be well worth it to make them out for more of the course. They helped me guide my reading and focus my attention on the important aspects of the material. The lecture notes used later as a substitute helped to consolidate the material, but led to more note-taking and less thinking since most of the questions were answered, not asked."

"As has been the case for the entire semester, the most interesting and striking sections were those with demonstrations. The transactionalist section and the Held section were certainly two of the most interesting of the semester. The demonstrations were not only fun, but made the material much clearer and more vivid in the memory."

COMMENTS ON SPECIFIC NOTES AND DEMONSTRATIONS

"I felt that the demonstrations were very useful in kinetic depth perception. Although the reading was pretty clear on this subject, it was still difficult to imagine what the subjects in these experiments were actually seeing. The same was even more true for the discussion of apparent motion of fixed objects such as the two dots. Not only seeing the motion but having the various phases of it pointed out was helpful."

"The class discussions were less than stimulating; I think that this was due to the fact that Hebb was so difficult. A lecture would have been helpful."

"The Swets reading was the most difficult that we have had in the course. I could not understand him at all; however, your reading notes helped immensely in clarifying terms; your reading notes greatly clarified many of Swets' constructs and more importantly gave us a good perspective into information theory."

"The time spent on the demonstrations of factors influencing perception of motion was wasted. The equipment just did not make it easy to see the relationships between the variables influencing the perception of movement."

"The class experiments on Fuchs' transparency helped considerably in understanding the readings. Much of the description of the set-up of equipment in Fuchs was meaningless if you didn't know what the equipment looked like. The class experiment should have been given before the reading of Fuchs.

The lecture notes on the quantitative study of form added breadth to the very brief Hochberg, McAlister "figural goodness" article."

"The mimeographed lectures and questions were very valuable. The demonstrations were good at the beginning, but often were weak in the last two weeks.

The structuralist section was covered adequately and interestingly in a short time. Here the class demonstrations with reduction screens, etc. were very effective in illuminating the structuralist method.

Demonstrations, like the Fuchs transparency one took so long, and worked so slightly that I felt some of the time would have better spent in discussion. One help with the demonstrations would be to have one student come in before the lab or class and prepare the demonstration with the instructor. Thus you would have at least one successful subject who could help the rest of the class to see the demonstration properly or at least to better understand what is supposed to happen. It would also help to introduce students to the use of lab equipment and technique.

The demonstration of the Wallach experiment was the most impressive and instructive. On the other hand, the demonstration of transparency didn't leave me with the feeling that seeing is believing."

"It was unfortunate that the Fuchs transparency demonstration did not work out as well as hoped, since the demonstrations are usually most helpful in understanding the difficult readings like Fuchs. The Wallach demonstration was good.

I find the reading notes and questions a very big aid, though I sometimes forget that they exist when I go to read the experiments. I feel that they are saving us a good deal of class time for demonstrations and our own questions."

COMPARISON OF NEW AND CONVENTIONAL PARTS OF THE COURSE

"The chief interest of this part of the course was in the demonstrations, both those of Gibsonian and transactionist theories and that of Held's. Unfortunately, the classes, without the reading and lecture notes to guide us, were not as clear as some of the earlier ones."

"The Class Demonstrations were great and made learning easier and more concrete. The dittoed notes were of immense help and should be extended to cover the entire course."

"As a final point I would like to say that it is unfortunate that we do not get any reading questions any longer. Although they were more important in providing cues to, for example, Kohler's work than they would be for Glanzer and Clark, they would be helpful in showing the student what points of reading must be taken with a grain of salt, what points are related specifically to other articles, etc."

"I still look back to the Golden Days when we had reading notes, and find that the Xeroxed lecture notes are too bare."

"The reading outlines were helpful in sifting out the main points of the reading. It is also a good idea to go over these outlines in class. One thing I missed from the previous unit, however, was the class demonstration, which did not occur often in this unit. (Of course I am aware that certain subjects lend themselves more readily to this kind of demonstration than others. I am merely pointing out that these demonstrations were helpful in fixing a point of information in the student's mind.)"

CRITICISM OF NOTES (This is an evaluation written by a student

"This was the first large section in the course in which we were not given fairly complete series of reading notes and questions, so it is now possible to assess the value of these study aids with a little more perspective. None of the readings in this section was so difficult and lengthy that these notes and questions would be essential to structure the material into some meaningful organisation, and perhaps for this reason they were not missed as much as they might have been. However, there are two possibilities:

first, that without these study aids the student must try to ask the questions himself and may be unable to perceive the real significance or the more subtle but crucial points in the article. On the other hand, it is a great temptation to use these aids as an actual reading guide, since they are listed in the same order as the topics they cover occur in article. Thus one may read along until the next question is applicable, slow down to answer it, and then speed up again. This puts a great burden on the adequacy of the study aids (which we were warned would not cover all the material we would be responsible for but nonetheless generally give the impression that they do). It also fails to force us to learn the basic skills necessary to read, understand, and critically evaluate experimental and theoretical material. For anyone entering the field of psychology, such skills may be far more valuable than any specific knowledge one might retain from undergraduate courses. Perhaps the reading notes and questions can serve as models for the development of such skills, but more likely they will merely be used and relied on rather than imitated."

# Appendix III

## Descriptions of Apparatus

## Gansfeld

The "Gansfeld" device provides for nearly completely homogeneous stimulation of an observer's entire visual field. A large curved screen (48" x 72") of translucent white plexiglass is evenly illuminated from behind while an observer sits in front of the screen (on the inside of the curve) with his face about 10 inches from the surface at the middle. Dark curtains behind the observer prevent light from striking the screen on the inside and causing unwanted reflections which would disturb the homogeneity of the field. Lights mounted at the top and bottom of the screen on the outside are directed toward any light-colored surface (preferably) a corner of the room) about five feet away. The light diffusely reflected from this surface provides the even illumination of the screen. The screen and its supporting frame are mounted on a dolly; this allows it to be rolled up to an observer and positioned appropriately in front of him.

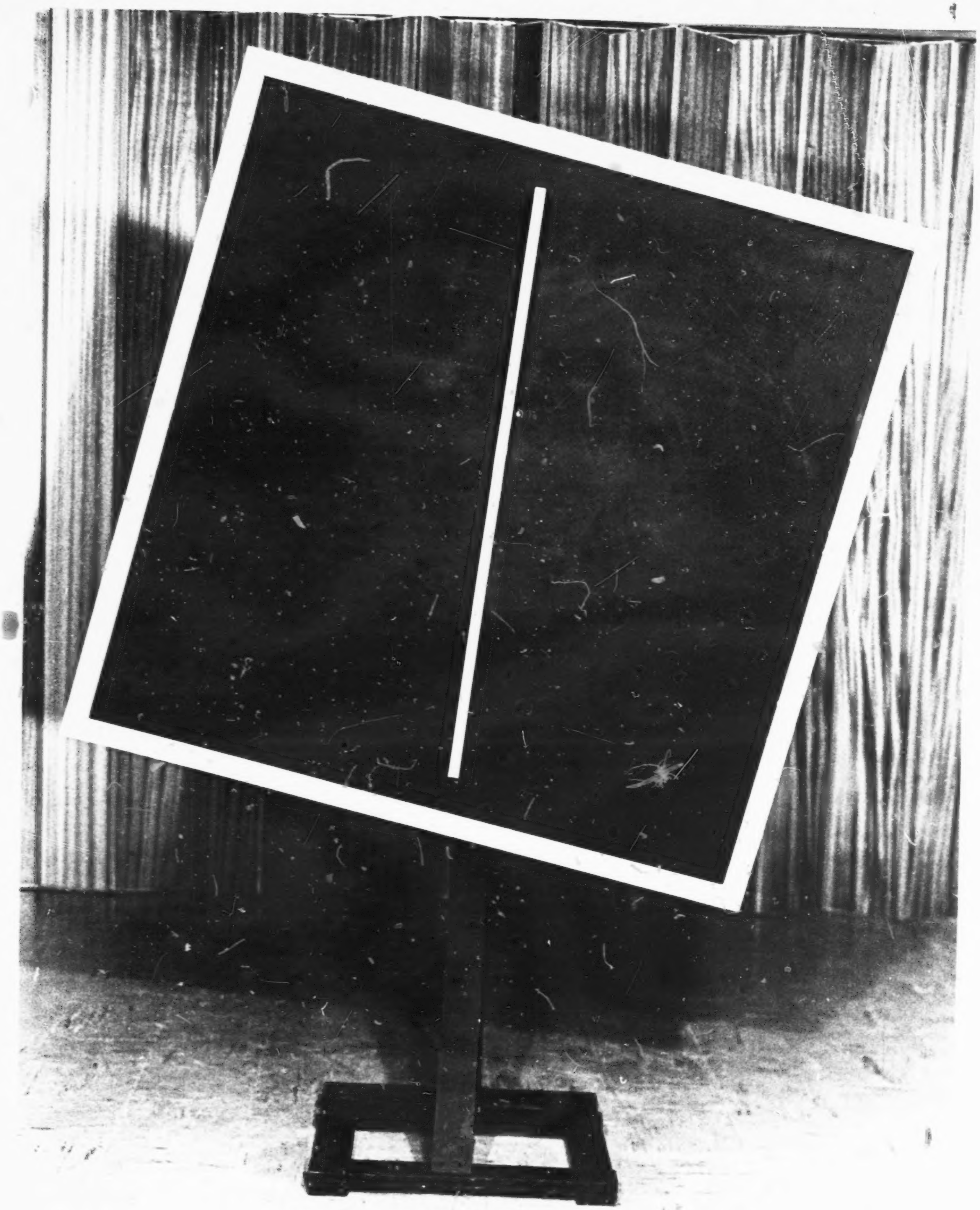
## Two-field Viewing Box

The two-field viewing box is a self-contained device for the monocular observation of two superimposed visual fields. A half-silvered mirror is mounted on an angle at the apex of an L-shaped box (each leg of the L measures 15" x 6" x 6") in such a way that an observer, looking through a small hole in the side of the box in front of the mirror, sees both ends of the box seemingly superimposed. At each end of the box in the top is a slit to allow the insertion of stimulus materials into the two fields. Each stimulus field is independently illuminated by small lights mounted inside the box, and the top of the box is hinged to allow access to the lights.

## Rod and Frame

The rod and frame apparatus consists simply of a large (4' x 4') frame of wood strips (1" wide, ½" thick) fastened to the edges of a masonite panel (4' x 4'), and a rod (3/4" x 3/4" x 46") supported at the center of the panel. Both the rod and its surrounding frame are painted with ultra-violet-reflecting paint, and during an experiment are illuminated from the front with a small ultra-violet light source. The rest of the apparatus is painted flat black, and cannot be seen during experiments.

The rod is fastened at its center to a small metal rod which passes through a hole at the center of the masonite panel, and which is attached to a slow-speed reversible motor behind the panel. By means of the motor, the rod can be rotated in either direction through a full 360° of arc. The angular orientation of the frame can also be adjusted somewhat (about 45° to either side of the vertical) with a thumbscrew arrangement behind the panel. The entire unit is mounted on a free-standing support which places the center of the frame about four feet from the floor. An observer sits about 8 feet in front of the apparatus and controls the rotational movement of the rod with the remote motor control. A compass rose and pointer arrangement fastened behind the masonite panel give the experimenter a means with which to assess the angular displacement of both the rod and the frame.



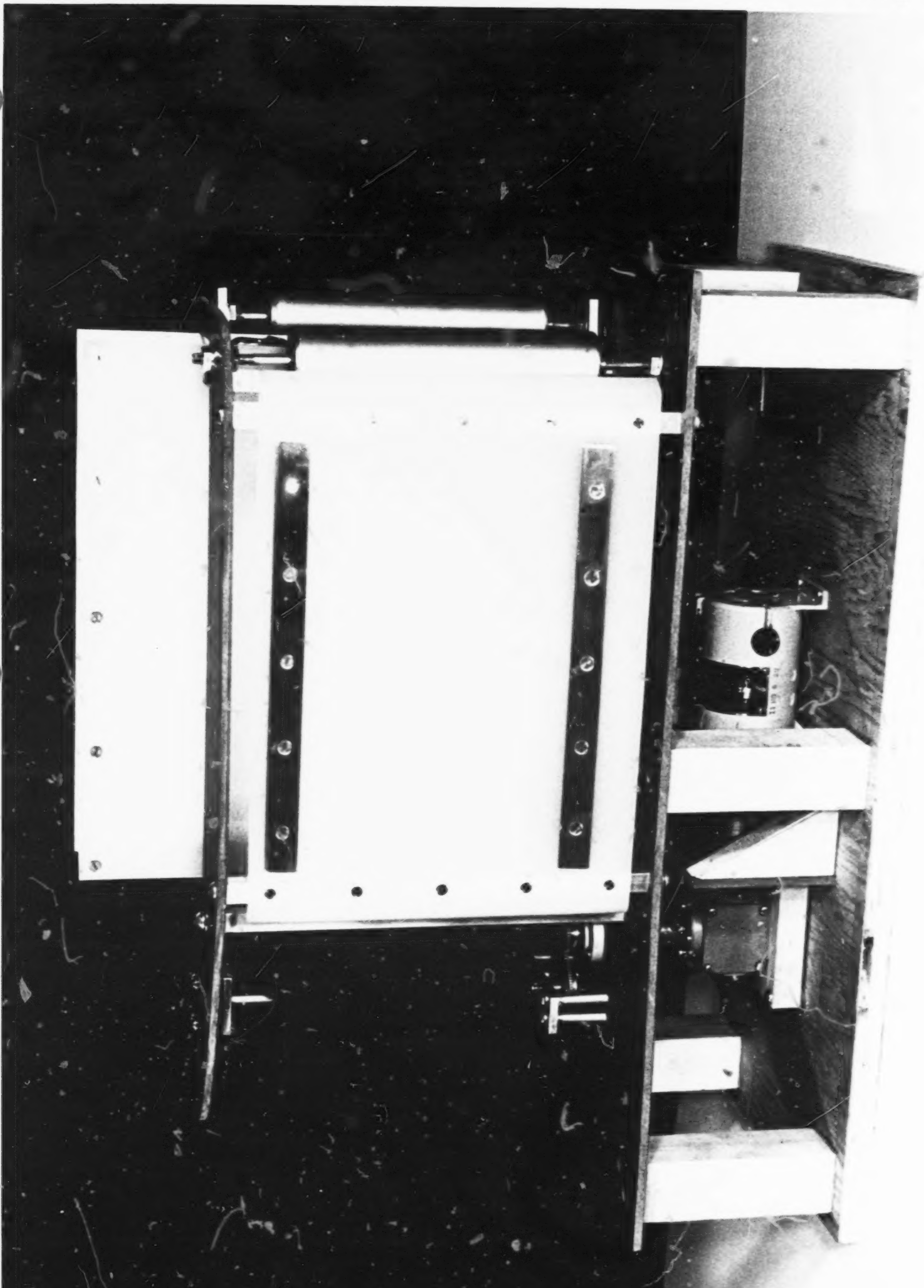
Motion Machines

The motion machines are devices for the simultaneous presentation of two different sets of moving figures; they are used in studies of perceived relative motion. Two identical units were constructed, each to present a single set of figures. Controls were provided on each unit to vary both the speed of motion of the figures (and also their direction, left or right), and their illumination.

Figures are displayed as cutouts on a continuous opaque belt, 6 inches wide and 54 inches long. The belt is illuminated from behind during rotation, making the figures appear as white objects on a black background. The belt is driven over an 8 x 10 inch plate of translucent white plexiglass, behind which is mounted the removable incandescent light unit. A large (6 inch diameter) drum serves as the driving wheel, and two smaller (2 inch diameter) rollers function as idler wheels. One of these rollers is spring mounted in such a way as to maintain constant tension on the belt. Aluminum guides on the plexiglass panel keep the belt from slipping up or down during machine operation.

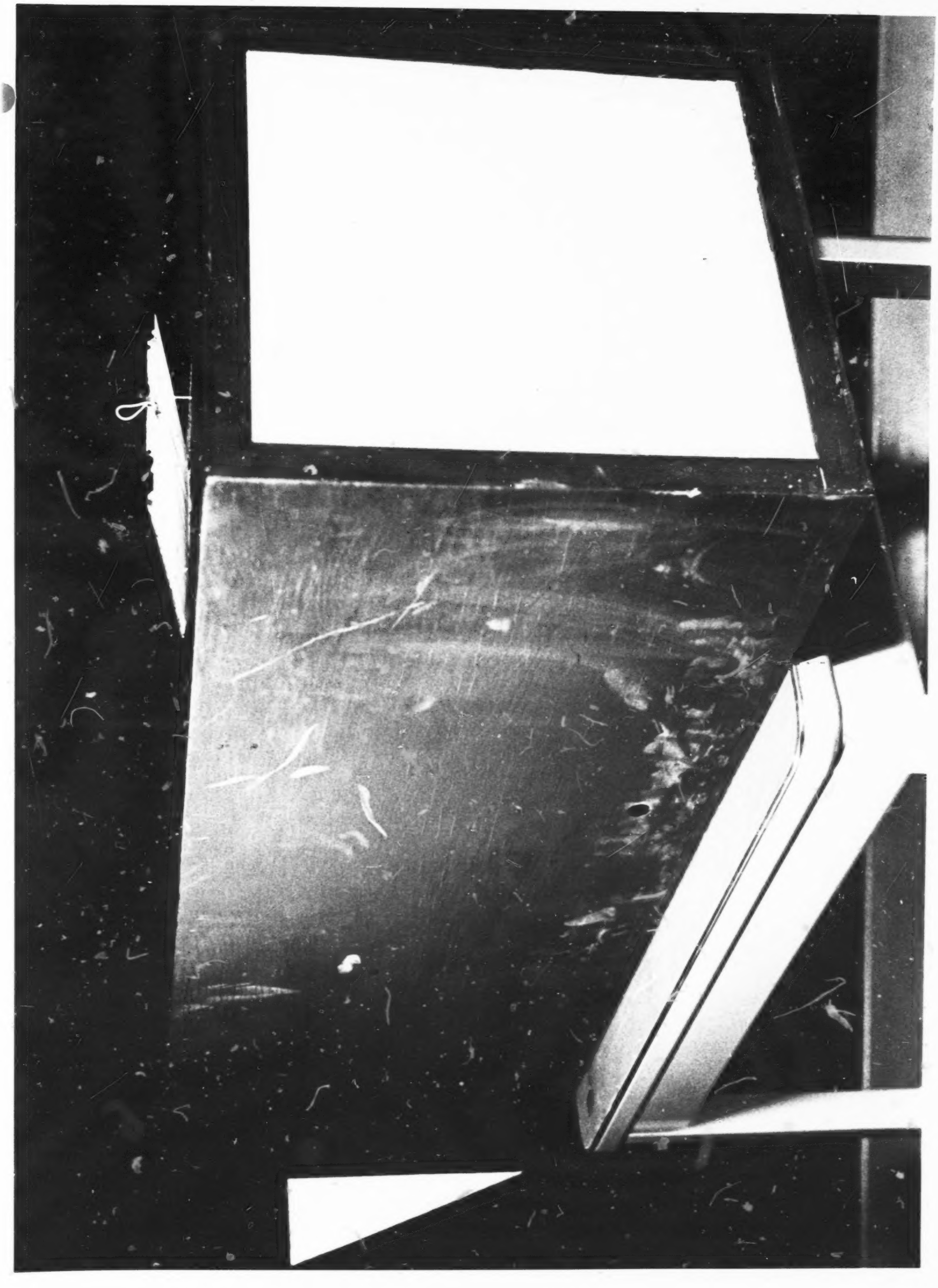
A high-speed, reversible, D.C. motor drives the main drum through a transmission consisting of a gear-reducer, a right-angle drive, and a set of external change gears. An electric clutch brake in the system allows the belt movement to be stopped or started instantly with the drive motor running. The belt speed can be adjusted over a wide range (10 inches/minute to 10 inches/second) both by varying the voltage delivered to the drive motor, and by using different sets of change gears. Illumination of the cutout figures is controlled by the use of an external variable transformer connected in the lamp circuit.

The entire unit is housed in a plywood box (20" x 10" x 12") with a window (5" x 8") cut in the front of the box for display of the moving figures. Tracks above and below the window on the outside of the box allow for the insertion of masks which can restrict the size of the display field. Power connections are made externally at the rear of the unit; also here are the connections for the remote stop-start speed control. Both units can be operated independently through this single remote control device.



## Kinetic Depth Effect Machine

The kinetic depth effect machine provides a convenient means for the projection of shadow images of rotating wire figures on a ground glass screen. A large box (6' x 2' x 2'), fitted at one end with a ground-glass screen, contains a small light source (actually a small slide projector) and a slow-speed reversible motor. The projector is mounted at the end of the box opposite the screen. About 10 inches in front of the screen the motor is mounted with its axle vertical. A wire figure is fastened in a hole in the motor axle so that operation of the motor causes the figure to rotate. Light from the projector casts a shadow image on the figure on the screen. Access doors are provided on the sides and top of the box for easy adjustment of the projector and replacement of the wire figures. The box is rested on a table in front of the observer for use; remote controls on the motor allow the observer to control the direction of rotation of the figures.

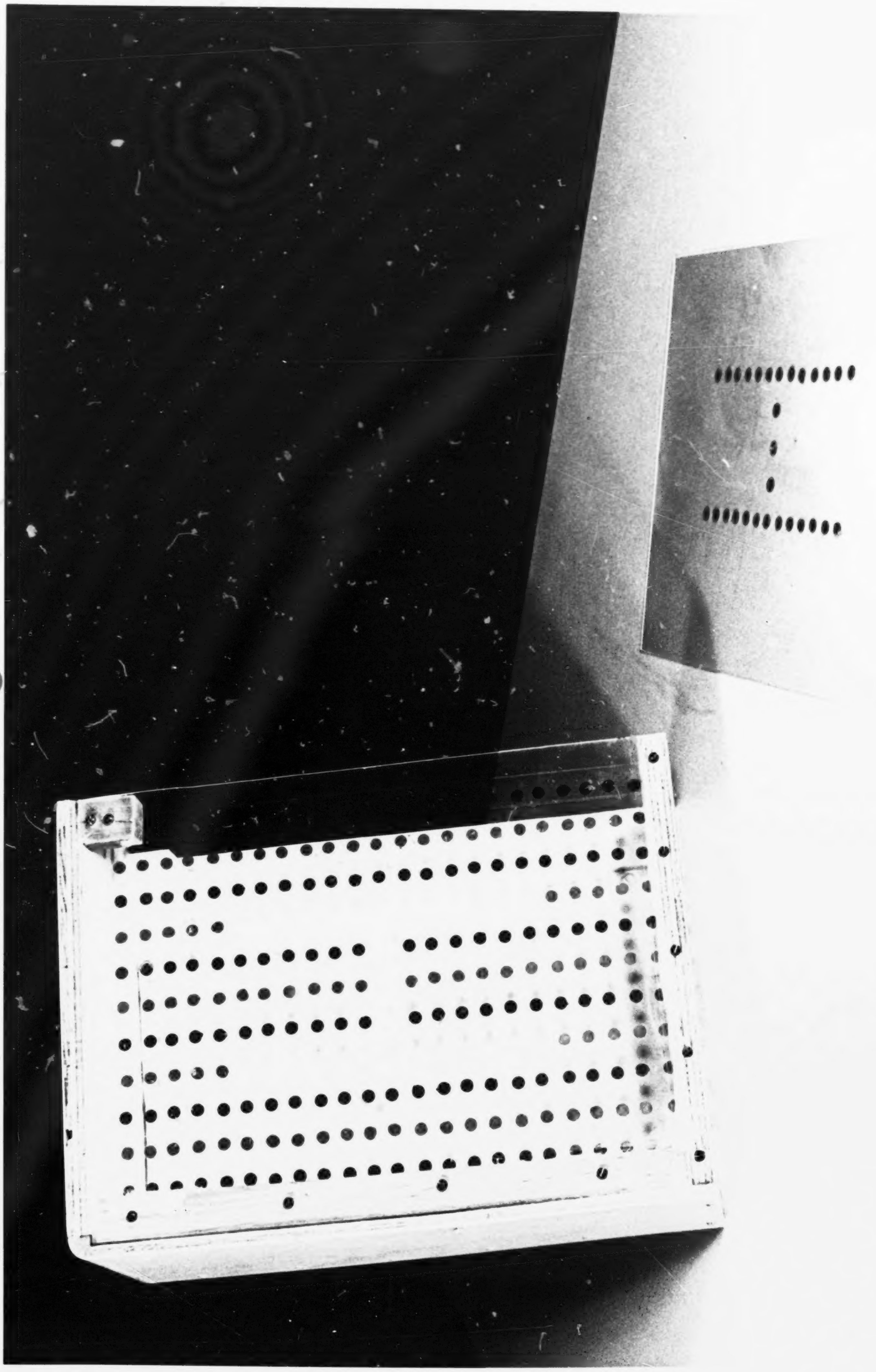


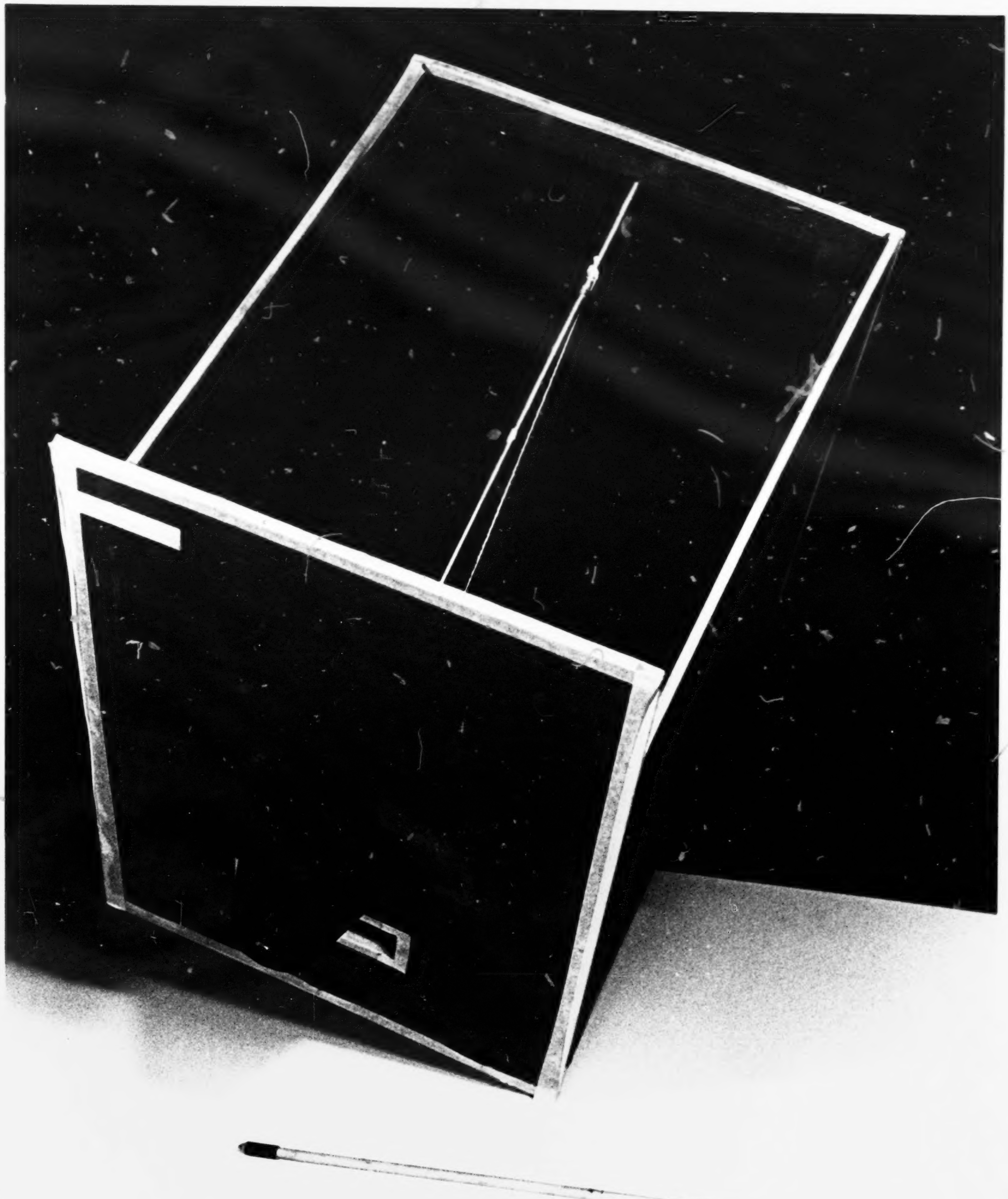
## Common-fate Box

The common-fate box is a five-sided box (12" x 12" x 4"), open on one side, in which are mounted three sheets of clear plastic, one inch apart. The front of the box also is of clear plastic. The inside sheets slide in and out in simple grooves cut in the top and bottom of the box. Groups of stimuli (e.g., dots) are mounted on each sheet in such a way that when viewed monocularly from the front they arouse different perceptions depending on the relative positions of the groups of stimuli.

## Equivalent Configuration Boxes

The equivalent configuration boxes are three identical masonite boxes (12" x 15" x 15"), open at the top, with a small viewing hole in the front. Mounted inside each box at the top and bottom are two rods which function as supports for the stimuli to be viewed through the hole in the front; the two rods cannot be seen through the hole, but stimuli suspended between them are clearly visible. Different stimuli are mounted in each box such that when viewed monocularly through the small hole in the front, each of them presents an equivalent configuration to the observer's eye. Through a second opening in the front of each box, the observer may insert a wooden pointer and touch the stimuli in order to become familiar with their real, not apparent, configurations. The stimuli and the ends of the pointers are painted with ultra-violet reflecting paint, and illumination of all three boxes is provided by a small ultraviolet source suspended above them.





## Thereness-thatness Machine

The thereness-thatness machine,modeled after the Ames demonstration apparatus,provides for the presentation of a fixed inspection stimulus superimposed on a controllable comparison field for use in studies of perceived distance. A dimly illuminated inspection stimulus, mounted on a black background, is set up at an appropriate distance from the observer off to his right or left; viewing is accomplished by means of a half-silvered mirror, mounted on a 45° angle to the observer's line of sight, from the eye. The comparison field is set up directly in front of the observer, and is viewed through the same half-silvered mirror; the two fields are seemingly superimposed, with the stimulus field being seen monocularly and the comparison field binocularly.

The controllable comparison field is the major part of the apparatus. It consists of three collapsible tables, each seven feet long and three feet high. The tables are placed end to end for use in experiments. Each table is made with two side rails (4 inches wide) and a central grooved track. A motor, cord, and pulley arrangement, mounted underneath the tables, is provided to drive a small cart (6" x 4" x 2") in either direction the entire length (20 feet) of the apparatus. The comparison stimulus is mounted on top of a dowel (¼" x 15"), which is fastened to the cart, and is illuminated by a small, battery-powered light inside the cart. The perceived length of the apparatus can be controlled by the construction of an artificial distance gradient on the side rails. Wooden dowels (½" x 15"), mounted on square wood bases serve this purpose nicely. They are set on the side rails at the required intervals along the entire length of the machine. The top ends of the dowels are painted with ultra-violet reflecting paint and are illuminated with ultra-violet light from above. The remaining portions of the apparatus are painted flat black, and experiments are run in a dark room, so that the observer sees nothing but the inspection stimulus, the comparison stimulus, and the gradient. His head is held stationary (in a comfortable head-rest) at one end of the machine. The half-silvered mirror is directly in front of one eye, while the other eye views the comparison field only. The subject looks straight ahead, down the length of the tables. The half-silvered mirror, mounted directly in front of the observer's open eye, allows him to see the dimly lit inspection stimulus apparently suspended in space beside the comparison stimulus. His task during an experiment is to move the cart and the comparison stimulus by means of the motor controls until both the inspection stimulus and the comparison stimulus seem to be the same distance from him.